

*13-99* *13-764* *(1)*

THE  
Carpenter's New Guide:

*4155*

BEING A

COMPLETE BOOK OF LINES

FOR

CARPENTRY AND JOINERY.

TREATING FULLY ON

Practical Geometry, Soffits, Brick and Plaister Groins, Niches of every Description, Sky-lights, Lines for Roofs and Domes, with a great variety of Designs for Roofs, Trussed Girders, Floors, Domes, Bridges, &c.;—Stair-cases and Hand-Rails of various Constructions; Angle Bars for Shop Fronts, &c.; and Raking Mouldings; with many other Things entirely new.

The whole founded on true Geometrical Principles; the Theory and Practice well explained, and fully exemplified

ON SEVENTY-EIGHT COPPER-PLATES,

CORRECTLY ENGRAVED BY THE AUTHOR.

INCLUDING

SOME OBSERVATIONS AND CALCULATIONS ON THE  
STRENGTH OF TIMBER.

BY

PETER NICHOLSON.

LONDON:

PRINTED FOR I. AND J. TAYLOR,

AT THE ARCHITECTURAL LIBRARY, No. 56, HIGH HOLBORN.

MDCCXCIII.



## 344

3 11 13/4

COMPLETE BOOK OF LINES

42-100-10

CARPENTRY AND JOINERY.



100

LETTER - HIGH NO 1304

1010

PRINTED FOR J. AND J. TAYLOR

AT THE ARCHITECTS' CHAMBER, 112, RUE DE LA HARPE, PARIS.



# P R E F A C E.

---

**T**O a book intended merely for the use of Practical Mechanics, much Preface is not necessary:—it is proper, however, to say, that whatever rules by previous authors have on examination proved to be true and well explained, these have been selected and adopted, with such alterations as a very close attention has warranted for the more easily comprehending them, for their greater accuracy or facility of application; added to these, are many examples which are entirely of my own invention, and such as will, I am persuaded, conduce very much to facilitate the workman, and to the accuracy of the work.

In this Second Edition the arrangement is gradual and regular, such as a student should pursue who wishes to attain a thorough knowledge of his profession; and as it is Geometry that lays down all the first principles of building, measures, lines, angles, and solids, and gives rules for describing the various kinds of figures used in buildings; therefore, as a necessary introduction to the art treated of, I have first laid down, and explained in the terms of workmen, such problems of Geometry as are absolutely requisite to the well understanding and putting in practice the necessary lines for Carpentry. These problems, duly considered, and their results well understood, the learner may proceed to the theoretical part of the subject, in which Soffits claim a very particular attention; for by a thorough knowledge of these, the student will be enabled to lay down arches which shall stand exactly perpendicular over their plan, whatever form the plan may be: on this depends the well executing all groins, arches, niches, &c. constructed in circular walls, or which stand upon irregular bases; wherefore the importance of rightly understanding these I cannot sufficiently insist on, their construction being so various and intricate, and their uses so frequently required.

The next subject which regularly presents itself is Groins; for the construction of which there will be found many methods entirely new; and besides the common figures, I have shewn many which are difficult of construction, and not to be found in any other author. I have displayed a large assortment of niches of each kind;

A

these



these are frequently wanted, those of the elliptic form only have yet been explained: in addition to these, here will be found schemes for globular ones, which occur frequently in practice.

Among the various methods for finding the Lines for Roofs, I have given an entire new one for finding the down and side bevels of purlines, so that they shall exactly fit against the hip rafter; and by the same method the jack rafter will be made to fit.

Of Domes and Polygons, I have shewn an entirely new method for finding their covering, within the space of the board, thereby avoiding the tedious and incommodious method of finding the lines on the dome itself, as has been always practised heretofore; also a method for finding the form of the boards near the bottom, when a dome is to be covered horizontally. Of Dome-lights over staircases, or in the centre of groins, a rule upon true principles is given, for finding their proper curve against the wall, and the curve of the ribs. This has never before been made public.

Having gone thus far in the Science of Carpentry (viz. through the theoretical part), it is necessary for me to say, by way of caution and guard to the ardent theorist, that there are on some surfaces curve lines which cannot be found absolutely true to one another; such as spherical or spheroidical domes, where their coverings cannot be found by any other means than by supposing them to become polygonal; in which case, they may be performed upon true principles, as may be demonstrated.—Let us suppose a polygonal dome inscribed in a spherical one; then, the greater the number of sides of the polygonal dome, the nearer it will coincide with its circumscribing spherical one.—Again, let us suppose that this polygon has an infinite number of sides; then, its surface will exactly coincide with the spherical dome, and therefore in any thing which we shall have occasion to practise, this method will be sufficiently near; as for example, in a dome of one hundred sides, of a foot each, the rule for finding such a covering will give the practice so very near, that the variation from absolute truth could not be perceived.

The Theory of Carpentry being now gone through, and I hope well studied and attended to; for the young student must not expect to be perfect master of this.



this intricate and important subject without some pains and application, notwithstanding the plain and clear manner in which I have endeavoured to lay down and explain those parts of his profession, which, on account of their importance, claim his utmost attention; and observe, that, in order to combine theory and practice, as well as to vary and enliven the subject, I have uniformly, with the theory, given examples of the practice, yet keeping them distinct and separate :

We now proceed to the Practical Part of Carpentry, in which is given a great variety of examples for floors, trusses, girders, roofs, domes, and partitions, on the newest and best principles.

In that nice and elegant branch of the Building Art, called Joinery, Stairs and Hand-rails take the lead; and notwithstanding the great importance of this subject, I am sorry to find it has been treated, by authors in general, in a very clumsy and slovenly manner. For Stair-cases, in general, I have laid down right methods, on principles entirely new, and which, since the publication of the former edition of this work, I have the satisfaction to say, have been put in practice, and found to answer well.

Various methods for diminishing Columns are shewn, together with two new ones, which I flatter myself are more easily adapted to practice; among other things of inferior note, is a method for finding the Lines of a circular Sash in a circular wall; also, a method, to the same purpose, for Architraves in a circular wall; neither of which have before been given, or explained. For mitring raking mouldings, I have, with some pains, confirmed a true method, not merely in theory, but by models, which I have by me, and am willing to shew, at convenient seasons, to any enquirer.

I must not here omit to observe, for though last not least, that my speculations and calculations on the strength of timber, will, I hope, be found particularly useful; and not merely so, but may also tend to induce others to consider this subject, whose leisure and abilities may lead to more important discoveries: I beg leave to add, that, to confirm the mathematical calculations, I have tried several of the questions by experiments. He who is a perfect master of this branch, may err in decoration, but never can in strength and proportion.



I beg leave to say of the Conclusion, it is intended to guard the young and incautious student against error; for wrong maxims are with more difficulty obliterated from the mind, than originally obtained.

To conclude; as I pretend not to infallibility, I hope to be judged with candour, being always open to conviction, from a knowledge of the difficulty and intricacy of science; yet I hope that my labours may be of some use to others, in shortening the road, and smoothing the path through which, for several years, I have been a persevering traveller for knowledge: I shall then be satisfied, and not deem time mispent, if my labours tend to the public good.

P. NICHOLSON.

P. S. In this Second Edition the arrangement of the subjects is progressive and regular; and besides eighteen additional plates, many of the others have been re-engraved, the subjects, in some, made more intelligible, and, in others, multiplied: So that this edition may be considered as a New Work.

CON



# C O N T E N T S

OF THE

## P L A T E S.

### GEOMETRY.

|                                                                                                                                                                            | Plate |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| <b>DEFINITIONS</b>                                                                                                                                                         | 1     |
| <i>Perpendiculars, bisecting angles, &amp;c.</i>                                                                                                                           | 2     |
| <i>Polygons, tangents, &amp;c.</i>                                                                                                                                         | 3     |
| <i>To describe figures whose dimensions are given, or to make one figure equal and similar to another, &amp;c.</i>                                                         | 4     |
| <i>To draw an arch of a circle to any given length and height, to describe an ellipsis to any given length and breadth, with compasses, or by ordinates</i>                | 5     |
| <i>To describe an ellipsis with a string, or trammet; to find the centre, and the two axes of an ellipsis; to proportionate an ellipsis about a parallelogram, &amp;c.</i> | 6     |
| <i>To describe the conic sections from a given cone</i>                                                                                                                    | 7     |
| <i>To describe elliptic arches, segments, &amp;c. by intersecting lines</i>                                                                                                | 8     |
| <i>To describe the sections of a cylinder, or any segment of a cylinder, whose plane is parallel to its axis, to any given angle whatever</i>                              | 9     |
| <i>To describe the sections of a globe, or any other solid generated by the revolution of any irregular figure about an axis</i>                                           | 10    |

### CARPENTRY.

|                                                                                                              |          |
|--------------------------------------------------------------------------------------------------------------|----------|
| <i>Of soffits parallel, fluing, or winding, in straight or circular walls</i>                                | 11 to 15 |
| <i>Given the form of an arch, to describe any other arch of the same height, of any given width whatever</i> | 15 To    |



|                                                                                                                                                   | Plate |
|---------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| <i>To describe the curb when a semicircular or elliptic window cuts above the ceiling line; to back and describe elliptic ribs with compasses</i> | 16    |

## B R I C K   G R O I N S.

|                                                                                               |    |
|-----------------------------------------------------------------------------------------------|----|
| <i>Centring for groins when level, the sides cutting through each other at right angles</i>   | 17 |
| <i>Ditto for inclined groins, when the intersection of the angles are given upon the plan</i> | 18 |
| <i>Centring for inclined groins when the side arches are given</i>                            | 19 |

## P L A I S T E R   G R O I N S.

|                                                                                                                                                                                  |    |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <i>Various methods to describe the ribs of a groin when parallel to the horizon</i>                                                                                              | 20 |
| <i>To describe the ribs when inclined to the horizon</i>                                                                                                                         | 21 |
| <i>To describe the arches of a groin parallel to the horizon, when the side arches cut under the body range, so as to have the angles straight upon the plan</i>                 | 22 |
| <i>To describe the intersecting ribs of a Welsh groin parallel to the horizon, the side arches being given, and cutting across each other at right angles</i>                    | 23 |
| <i>To describe the intersecting ribs of a Welsh groin parallel to the horizon, standing upon a bevel plan</i>                                                                    | 24 |
| <i>To describe the intersecting ribs of an octagon groin parallel to the horizon, the side arches being given</i>                                                                | 25 |
| <i>To find the intersecting body ribs of a circular groin parallel to the horizon, when the side arches are given, and the intersection of the angles straight upon the plan</i> | 26 |
| <i>Having the inclination of a circular groin, and one of the body ribs, to find the intersecting and side ribs</i>                                                              | 26 |

## N I C H E S.

|                                                                                                                                                     |    |
|-----------------------------------------------------------------------------------------------------------------------------------------------------|----|
| <i>The plan of a globular niche being a given segment, and the front rib a semicircle, to find the sweep of the back ribs</i>                       | 27 |
| <i>To find the sweep of the back ribs of a globular niche when the plan and front rib are segments of the same width, but of different breadths</i> | 28 |
| <i>The plan of a semicircular niche being given, standing in a circular wall, to find the front and back ribs</i>                                   | 29 |
| <i>The plan or elevation of an elliptic niche being given, to describe the back ribs</i>                                                            | 30 |

## S K Y - L I G H T S.

|                                                                                    |    |
|------------------------------------------------------------------------------------|----|
| <i>To find the mitres or bevells of the stiles of sky-lights to any plan given</i> | 31 |
|------------------------------------------------------------------------------------|----|

L I N E S





# CONTENTS.

xi

## LINES IN ROOFING.

|                                                                                                                                                                                                      | Plate |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------|
| To find the length and backings of hip rafters, and the form of the ends of a purline standing against them; also the proper forms of the ends of the jack rafters, where they come against the hips | 32    |
| To lay a square roof in ledgment                                                                                                                                                                     | 33    |
| To lay a winding roof in ledgment                                                                                                                                                                    | 34    |
| To find the hips, and to cover all manner of polygon roofs, without drawing the covering from the plan                                                                                               | 35    |
| To cover a dome with horizontal boards                                                                                                                                                               | 36    |
| To draw the ribs of an elliptic dome, and to find the form of the covering                                                                                                                           | 37    |
| To find the sections of domes placed over a stair-case, or when it is placed between the intersections of groins                                                                                     | 38    |
| To find the sections of an elliptic dome, placed in the same manner, and to describe the ribs                                                                                                        | 39    |

## PRACTICAL CARPENTRY.

|                                                               |          |
|---------------------------------------------------------------|----------|
| Trussing of girders                                           | 40       |
| Roofs suited for various purposes                             | 41 to 49 |
| Story posts, and the manner of framing and piling of a bridge | 50       |

## JOINERY.

### OF STAIRS AND HAND-RAILS.

|                                                                                                                |          |
|----------------------------------------------------------------------------------------------------------------|----------|
| To find the mitre cap of a rail, the section of the rail being given                                           | 51       |
| A dog-leg stair-case, with a half space                                                                        | 52       |
| A dog-leg stair-case, with winders all round                                                                   | 53       |
| To describe the scroll of a hand-rail—to find the face mould and the falling mould to any given pitch whatever | 54       |
| To find a face mould for getting a scroll out of a solid piece of wood                                         | 55       |
| The plan and section of a geometrical stair-case circular on the plan, upon a level landing                    | 56       |
| To find the moulds of ditto when the opening is small                                                          | 57       |
| To find the moulds of a stair-case circular on the plan, with a quarter space in it                            | 59       |
| To find the moulds of ditto, with winders all round                                                            | 60 to 61 |



|                                                                                                                                                                   | Plate    |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| <i>The plan and section of an elliptical stair-case</i>                                                                                                           | 62       |
| <i>To find the moulds of ditto</i>                                                                                                                                | 63       |
| <i>The plan of a stair-case being given, to diminish the ends of the steps at the rail regularly, so that the bannisters shall be all regular</i>                 | 64       |
| <i>Ditto when there is a half space on the side</i>                                                                                                               | 65       |
| <i>To cap an iron rail</i>                                                                                                                                        | 66       |
| <i>To glue a rail up in thickness, and to trace the brackets round the winders</i>                                                                                | 67       |
| <i>To fit the skirting to any kind of stairs straight or circular</i>                                                                                             | 68       |
| <i>Various methods of diminishing columns</i>                                                                                                                     | 69       |
| <i>How to find the bars for a circular circular sash</i>                                                                                                          | 70       |
| <i>How to find an archivolt to a circular circular window</i>                                                                                                     | 71       |
| <i>To find the angle bars of shop fronts, and raking mouldings for pediments</i>                                                                                  | 72       |
| <i>Ditto for stair-cases</i>                                                                                                                                      | 73       |
| <i>To diminish or enlarge a cornice—the method of finding the joint of a jib door</i>                                                                             | 74       |
| <i>To find the proper curve of a board to be bent round a cylinder, so that it shall stand to any angle given, and be parallel to the horizon when bent round</i> | 75       |
| <b>CONCLUSION</b>                                                                                                                                                 | 76 to 78 |





---

OF

# PRACTICAL GEOMETRY.

---

**G**EOMETRY is the science of extension and magnitude ; it teaches the construction of all right lined and curvilinear figures, and is divided into Theoretical and Practical.

The Theoretical part is founded upon reason and self-evidence ; it demonstrates the construction of variously formed figures, and evinces the truth, or detects the falsehood on which they are made. This is the foundation of the Practical part ; and without a knowledge of the Theory, no invention to any degree certain can be made in the Practice. The uses of Geometry are not confined to Carpentry and Architecture, but, in the various branches of the Mathematics, it opens and discovers to us their secrets. It teaches us to contemplate truths, to trace the chain of them, subtle and almost imperceptible as it frequently is, and to follow them to the utmost extent.

Its uses are great and necessary in Astronomy and Geography. The science of Perspective is entirely dependent upon its principles. To enumerate its many uses is beyond my power. Those who desire to become thoroughly acquainted with Geometry, will do well to study attentively the Elements of Euclid.

As my labours are not intended for the abstruse Mathematician, but for the instruction of the *Practical Carpenter*, I shall omit all speculative demonstrations, the sections of Cylinders and Globes excepted (which are not to be found in Euclid), and confine myself to the useful part of the science, viz. PRACTICAL GEOMETRY.

## P L A T E I.

### D E F I N I T I O N S.

1. *A POINT* hath neither parts nor magnitude.

2. *A line* is length, without breadth or thickness.

B

3. *A superficies*



3. A superficies hath length and breadth only.

4. A solid is a figure of three dimensions, having length, breadth, and thickness.

Hence surfaces are the extremities of solids, and lines the extremities of surfaces, and points the extremities of lines.

5. Lines are either right, curved, or mixed of these two.

6. A right or straight line lies all in the same direction between its extremities, and is the shortest distance between two points, as A.

7. A curve continually changes its directions between its extreme points, as C.

8. Lines are either parallel, oblique, perpendicular, or tangential.

9. Parallel lines are always at the same distance, and will never meet, though ever so far produced, as D and E.

10. Oblique right lines change their distance, and would meet, if produced, as F.

11. One line is perpendicular to another when it inclines no more to one side than another, as G.

12. One line is a tangent to another when it touches it without cutting, when both are produced, as H.

13. An angle is the inclination of two lines towards one another in the same plane, meeting in a point, as I.

14. Angles are either right, acute, or oblique, as K.

15. A right angle is that which is made by one line perpendicular to another, or when the angles on each side are equal, as G.

16. An acute angle is less than a right angle, as K.

17. An obtuse angle is greater than a right angle, as L.

18. A superficies is either plane or curved.

19. A plane, or plane surface, is that to which a right line will every way coincide;—but if not, it is curved.

20. Plane figures are bounded either by right lines or curves.

21. A solid is said to be cut by a plane when it is cut through in any particular place, and the place that is cut is called the section of the solid.

22. Plane figures, bounded by right lines, have names according to the number of their sides, or of their angles, for they have as many sides as angles—the least number is three.

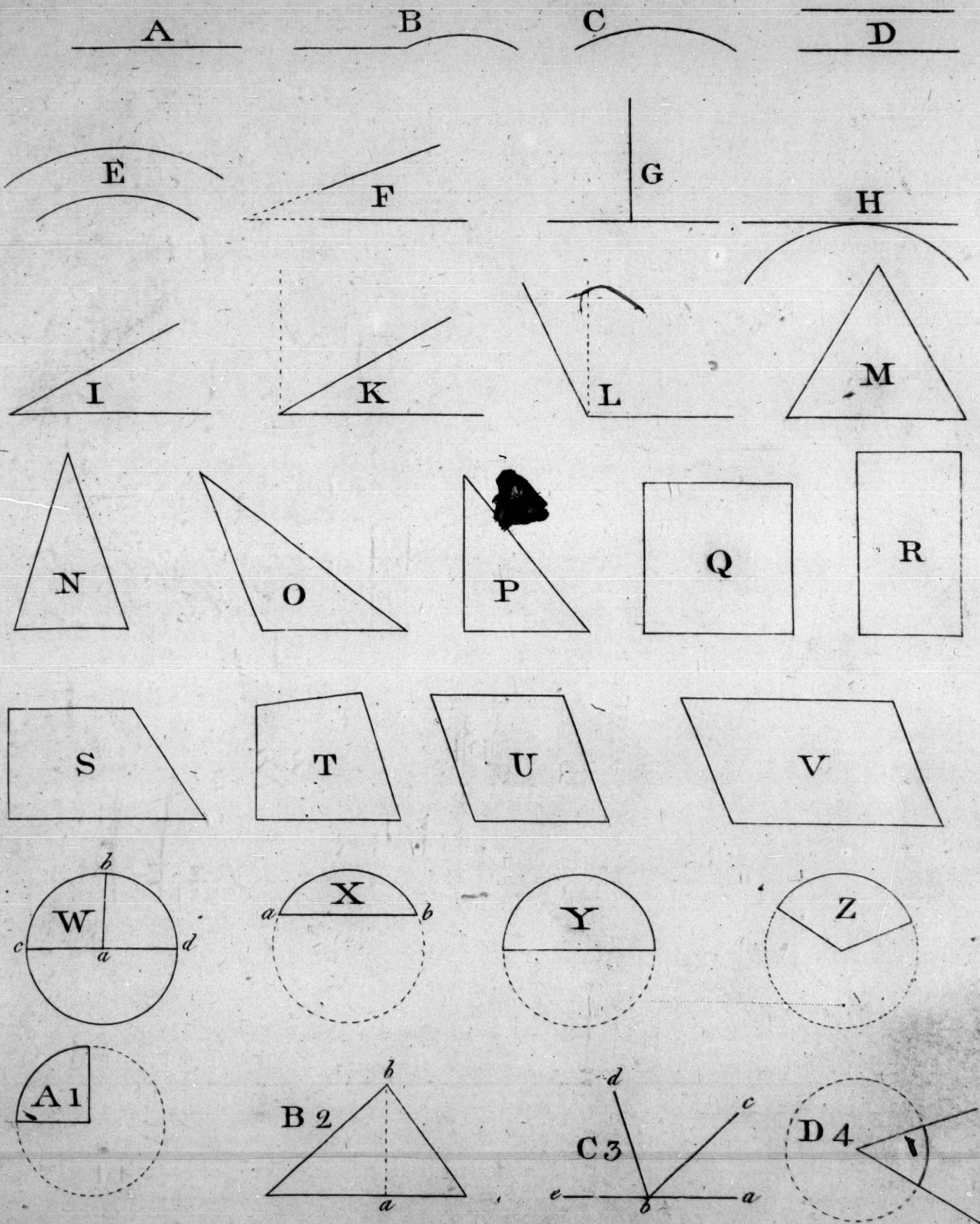
23. An equilateral triangle is that whose three sides are equal, as M.

24. An





Plate 1









24. *An isosceles triangle has only two sides equal, as N.*
25. *A scalene triangle has all sides unequal, as O.*
26. *A right angled triangle has one right angle, as P.*
27. *Other triangles are oblique angled, and are either obtuse or acute.*
28. *An acute angled triangle has all its angles acute, as M or N.*
29. *An obtuse angled triangle has one obtuse angle, as O.*
30. *A figure of four sides and angles is called a quadrangle, or quadrilateral, as Q, R, S, T, U and V.*
31. *A parallelogram is a quadrilateral, which has both pairs of its opposite sides parallel, as Q, R, U and V; and takes the following particular names.*
32. *A rectangle is a parallelogram having all its angles right ones, as Q and R.*
33. *A square is an equilateral rectangle, having all its sides equal, and all its angles right ones, as Q.*
34. *A rhombus is an equilateral parallelogram, whose angles are oblique, as U.*
35. *A rhomboid is an oblique angled parallelogram, as V.*
36. *A trapezium is a quadrilateral which has neither pair of its sides parallel, as T.*
37. *A trapezoid hath only one pair of its opposite sides parallel, as S.*
38. *Plane figures having more than four sides, are in general called polygons, and receive other particular names according to the number of their sides or angles.*
39. *A pentagon is a polygon of five sides, a hexagon hath six sides, a heptagon seven, an octagon eight, a nonagon nine, a decagon ten, an undecagon eleven, and a dodecagon twelve sides.*
40. *A regular polygon hath all its sides and its angles equal; and if they are not equal, the polygon is irregular.*
41. *An equilateral triangle is also a regular figure of three sides, and a square is one of four; the former being called a trigon, and the latter a tetragon.*
42. *A circle is a plane figure bounded by a curve line called the circumference, which is everywhere equidistant from a certain point within, called its centre.*
43. *The radius of a circle is a right line drawn from the centre to the circumference, as a b at W.*
44. *A diameter of a circle is a right line drawn through the centre, terminating on both sides of the circumference, as c d at W.*



45. An arch of a circle is any part of the circumference.
46. A chord is a right line joining the extremities of an arch, as  $a b$  at X.
47. A segment is any part of a circle bounded by an arch and its chord, as X.
48. A semicircle is half the circle, or a segment cut off by the diameter, as Y.
49. A sector is any part of a circle bounded by an arch and two radii, drawn to its extremities, as Z.
50. A quadrant, or quarter of a circle, is a sector having a quarter of the circumference for its arch, and the two radii are perpendicular to each other, as A 1.
51. The height or altitude of any figure is a perpendicular let fall from an angle, or its vertex, to the opposite side, called the base, as  $a b$  at B 2.
52. When an angle is denoted by three letters, the middle one is the place of the angle, and the other two denote the sides containing that angle: thus let  $a b c$  be the angle at C 3,  $b$  is the angular point, and  $a b$  and  $b c$  are the two sides containing that angle.
53. The measure of any right lined angle is an arch of any circle contained between the two lines which form the angle, and the angular point being in the centre, as D 4.

## P L A T E II.

## P R O B L E M S.

FIGURE 1. To draw a perpendicular to a given point in a line.

$A B$  is a line, and  $c$  a given point; take  $a$  and  $b$ , two equal distances on each side of  $c$ , and with your compasses in  $a$  and  $b$  make an intersection  $d$ , and draw  $d c$ , which is the perpendicular.

FIG. 2. To make a perpendicular with a ten foot rod.

Let  $a b$  be six feet, then take eight feet and make an arch at  $c$  in the point  $b$ , and in the point  $a$  with the distance ten feet cross at  $c$ , then draw  $c b$ , which is the perpendicular.

FIG. 3. To let fall a perpendicular from a given point to a line.

In the given point  $c$  make an arch to cross the line in  $a$  and  $b$ , and in  $a$  and  $b$  make an intersection at  $d$ , and draw  $c d$ , the perpendicular.

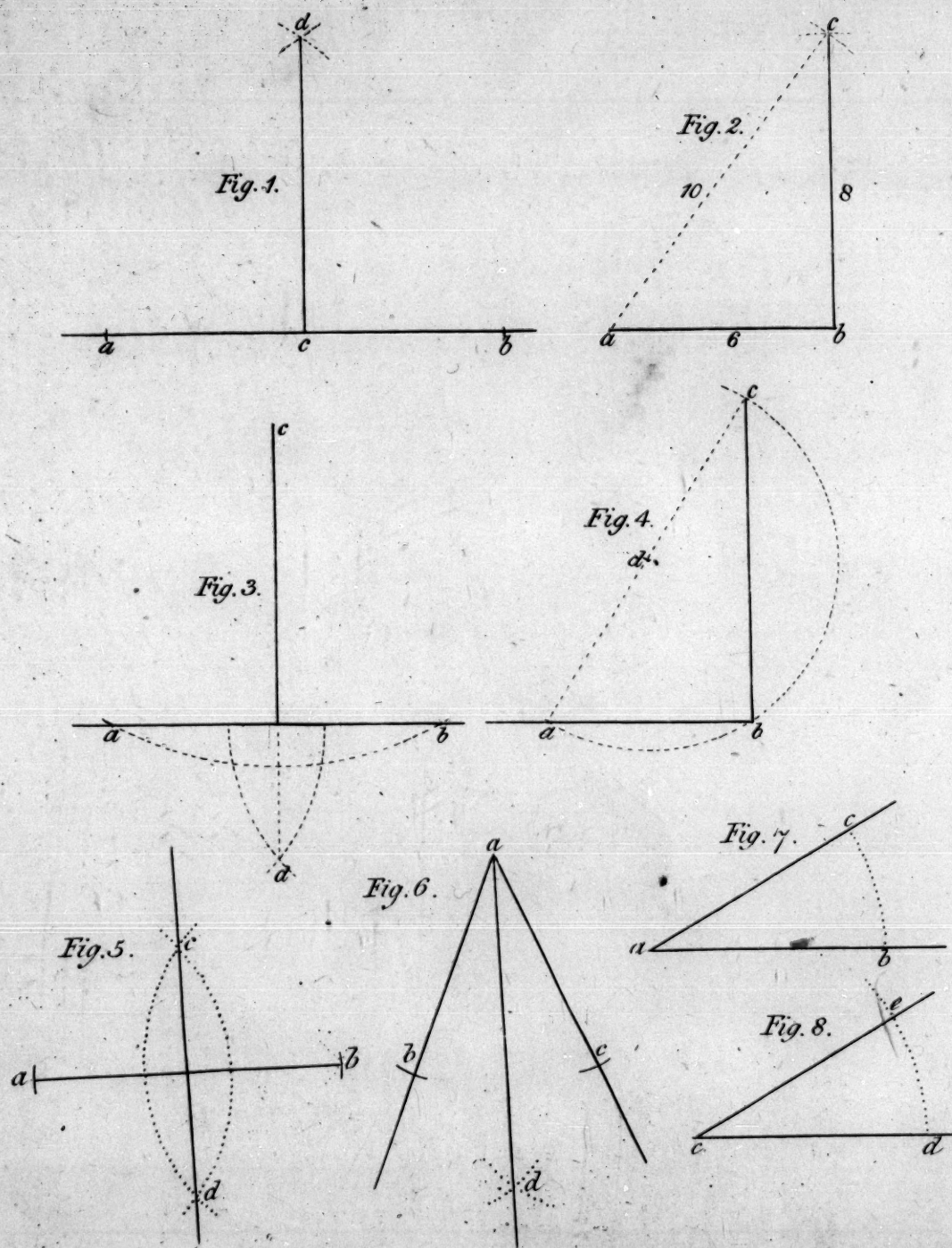
FIG. 4. To draw a perpendicular upon the end of a line.

Take any point at pleasure above the line, and with the distance  $d b$  make an arch  $a b c$ , and draw a line  $a d$  to cross it at  $c$ , and draw  $c b$  the perpendicular.

FIG. 5.



Plate 2.



Pub. as the Act directs June 6, 1792. by P. Nicholson.











Plate 3

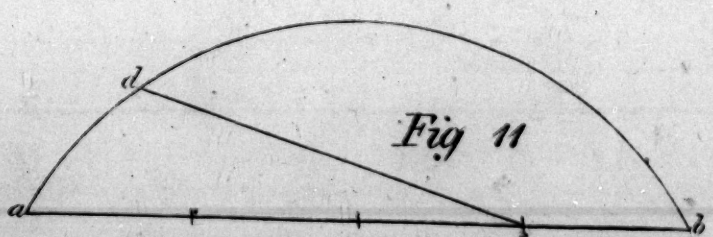
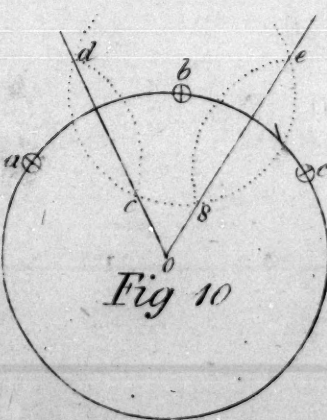
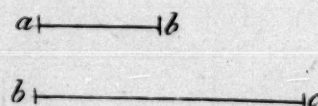
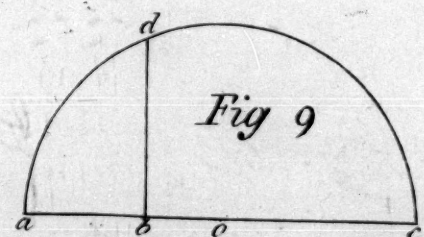
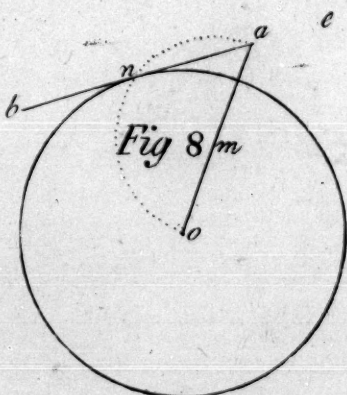
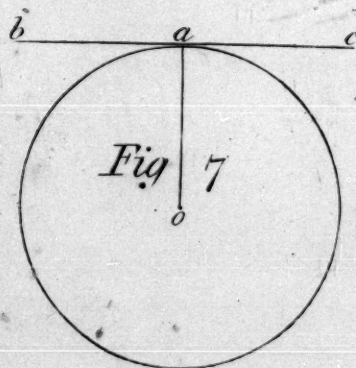
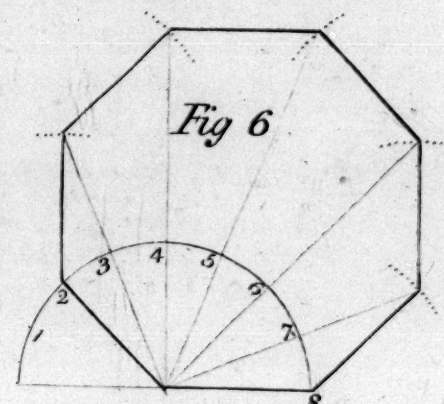
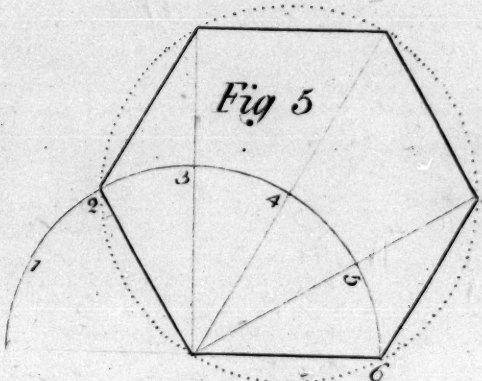
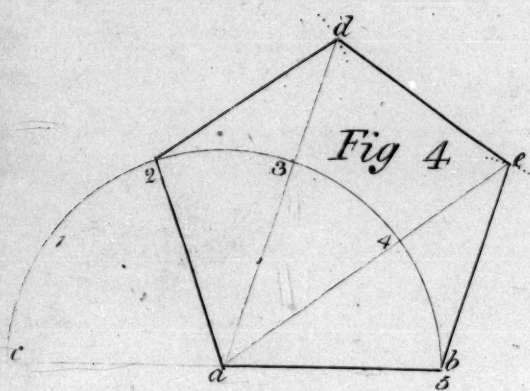
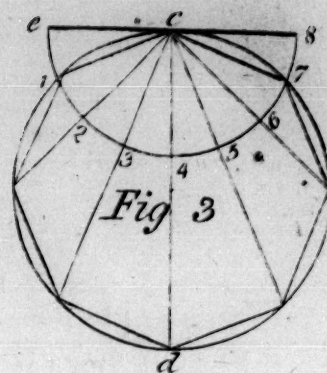
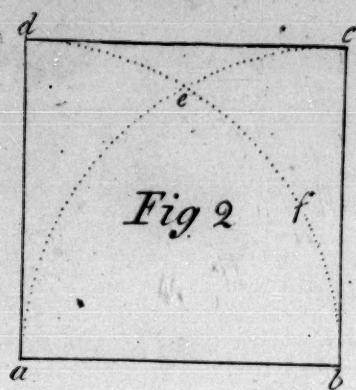
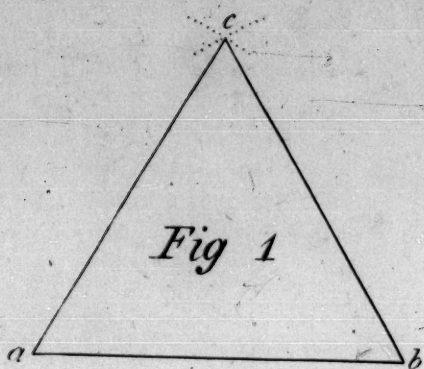




FIG. 5. *To divide a line in two parts by a perpendicular.*

In the points  $a$  and  $b$  describe two arches to intersect at  $c$  and  $d$ , and draw  $cd$ , which divides the line in two.

FIG. 6. *To divide any given angle into two equal angles.*

Take two equal distances  $b$  and  $c$  on each side of the angular point  $a$ , and with the same opening of the compass on any other place the foot of your compass in  $b$  and  $c$ , make an intersection at  $d$ , and draw  $da$ , which will divide the angle into two equal parts.

FIG. 7 and 8. *An angle being given, to make another equal to it, from a given point, in a right line.*

Let  $bac$  be the angle given, and  $cd$  a right line,  $c$  the given point; on  $a$  make an arch  $bc$  with any radius, and on  $c$  with the same radius describe an arch  $de$ , take the opening of  $bc$ , set it from  $d$  to  $e$ , and draw  $ec$ , then the angle  $ecd$  will be equal to  $cab$ .

### PLATE III.

FIG. 1. *Upon a right line to make an equilateral triangle.*

Take  $ab$  the given side with your compass, place one foot in  $a$  and  $b$ , make an intersection at  $c$ , and draw  $ca$  and  $cb$ .

FIG. 2. *Upon a right line to make a geometrical square.*

With the given side  $ab$ , and in the points  $a$  and  $b$ , describe two arches to intersect at  $e$ , divide  $be$  into two equal parts at  $f$ , make  $ed$  and  $ec$  each equal to  $ef$ , draw  $ad$ ,  $dc$ , and  $cb$ .

FIG. 3. PROPOSITION.

If through the point  $c$  in the extreme of the diameter  $cd$ , is drawn a tangent line  $ec$ , and if on this point  $c$  with any radius a semicircle be described and divided into equal parts, and from the centre  $c$  lines be drawn through these points to terminate in the circumference, it will be divided into equal parts.

FIG. 4, 5, 6. *The side of any polygon being given, to describe the polygon to any number of sides whatever.*

On one extreme of the given side make a semicircle of any radius, but it will be most convenient to make it equal to the side of the polygon; then divide the semicircle into the same number of equal parts as you would have sides in the polygon, and draw lines from the



the centre through the equal divisions in the semicircle, always omitting the two last, and run the given side round each way upon these lines, join each side, and it will be completed.

*Example in a pentagon, Fig. 4.*

Let  $ab$  be the given side, and continue it out to  $c$ , on  $a$ , as the centre and the given side, describe a semicircle, divide it into five equal parts, through 2, 3, 4, draw  $a2$ ,  $a4$ ,  $a5$ , make  $be$  equal to  $ab$ ,  $2d$  equal to  $2a$  or  $ab$ , join  $2d$ ,  $d5$ , and  $e5$ . In the same manner may any other polygon be described.

FIG. 7. *Through a given point  $a$  to draw a tangent to a given circle.*

From  $a$  draw  $ao$  to the centre, then through  $a$  draw  $bc$  perpendicular to  $ao$ , it will be the tangent.

FIG. 8. *A tangent line being given, to find the point where it touches the circle.*

From any point  $a$  in the tangent line  $bc$ , draw a line to the centre  $o$ , and divide  $ao$  into two equal parts at  $m$ , and with a radius  $ma$ , or  $mo$ , describe an arch, cutting the given circle in  $n$ , which is the point required.

FIG. 9. *Two right lines being given, to find a mean proportion.*

Join  $ab$  and  $bc$  in one straight line, divide it into two equal parts at the point  $o$ , with the radius  $oa$  or  $oc$  describe a semicircle, and erect the perpendicular  $bd$ , then is  $ab$  to  $bd$  as  $bd$  is to  $bc$ .

FIG. 10. *Through any three points to describe the circumference of a circle.*

From the middle point  $b$  draw chords  $ba$  and  $bc$  to the two other points  $a$  and  $c$ , divide the chords  $ab$  and  $bc$  into two equal parts by perpendiculars meeting at  $o$ , which will be the centre.

FIG. 11. *To find a right line equal to any given arch of a circle.*

Divide the chord  $ab$  into four equal parts, set one part  $bc$  on the arch from  $a$  to  $d$ , and draw  $dc$ , which will be nearly equal to half the arch.

*Note.* This method should not be used above a quarter of a circle; so that if you would find the circumference of a whole circle by this method, the fourth part must only be used, which will give one eighth part of the whole exceedingly near.

## PLATE IV.

FIG. 1. *Any three lines being given, to make a triangle.*

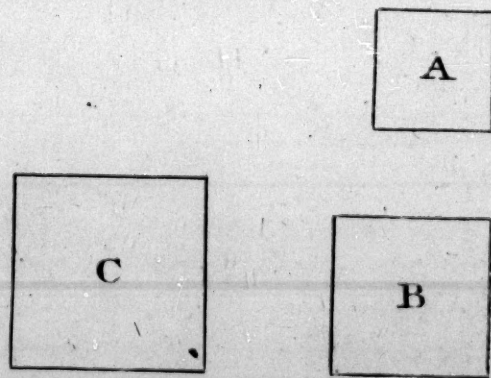
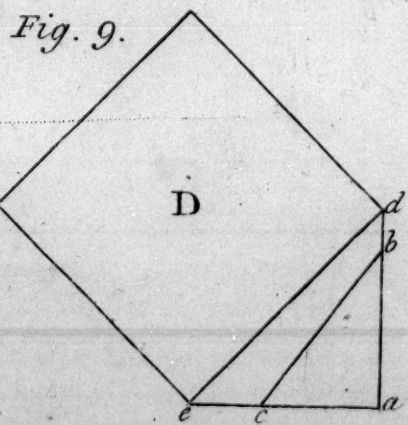
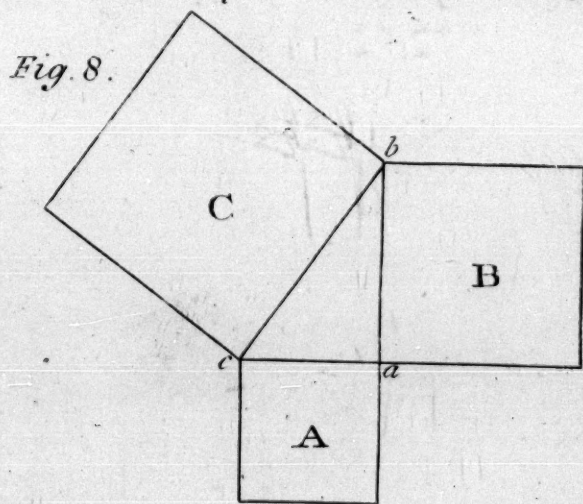
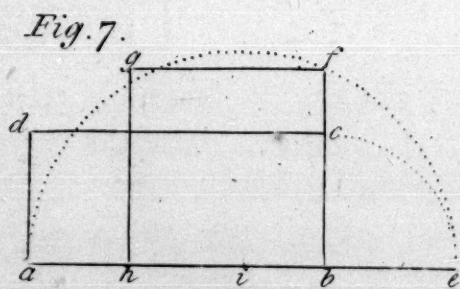
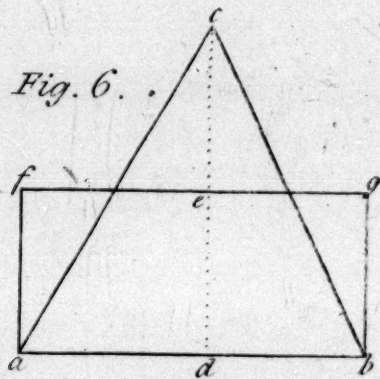
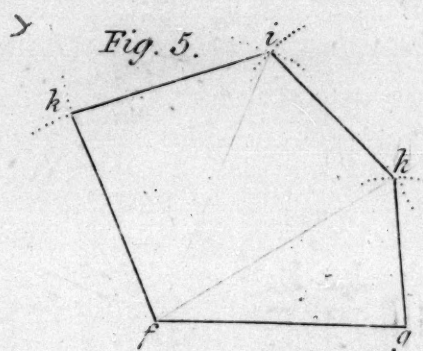
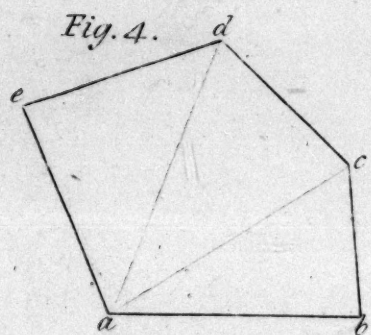
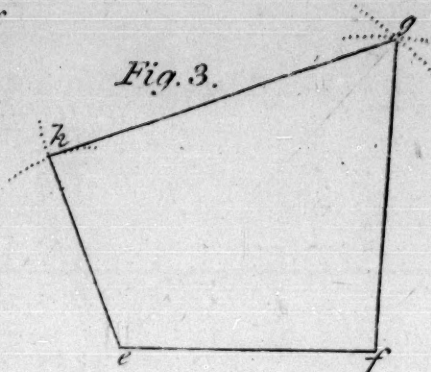
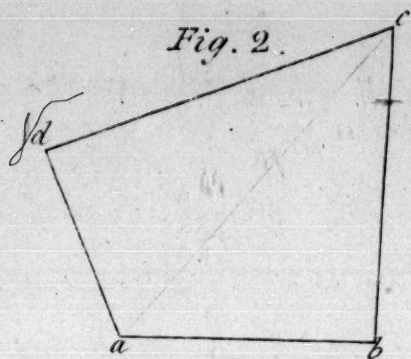
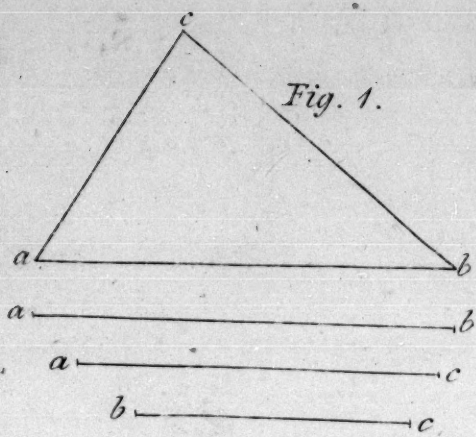
Take one of the given sides  $ab$ , and make it the base of the triangle; take the other side  $ac$ ,







Plate 4.





$a c$ , and put the foot of the compass in  $a$ , and make an arch at  $c$ ; then take the third side  $b c$ , and put the foot of the compass in  $b$ , and cross the other arch at  $c$ ; join the sides.

*Note:* That any two lines must be greater than a third.

FIG. 2, 3. *To make a quadrangle equal to a given quadrangle.*

Divide the given quadrangle, fig. 2, in two triangles; make the triangle  $e g f$  equal to  $a b c$ , and  $e g b$  equal to  $a c d$ , and it is done.

FIG. 4, 5. *Any irregular polygon being given, to make another of the same dimensions.*

Divide the given polygon into triangles, and in fig. 5, make triangles in the same position, respectively equal to those in fig. 4; then will the irregular polygon  $f, g, h, i, k$ , be equal and similar to  $a b c d e$ : in the same manner may any other polygon be made equal and similar to another.

FIG. 6. *To make a rectangle equal to a given triangle.*

Draw a perpendicular  $c d$ , divide it into two equal parts at  $e$ , through  $e$  draw  $f g$ , parallel to the base  $a b$ , draw  $a f, b g$ , perpendicular; then will the rectangle  $a b g f$  be equal to the triangle  $a b c$ .

FIG. 7. *To make a square equal to a given rectangle.*

Let  $a b c d$  be the given parallelogram; continue one of its sides as  $a b$  out to  $h$ , make  $b e$  equal to the other side  $b c$ , divide  $a e$  in two equal parts at  $i$ , with the radius  $i e$  or  $i a$  make a semicircle  $a f e$ , and draw  $b f$  perpendicular to  $a b$ ; make the square  $b f g h$ , which is equal to the parallelogram  $a b c d$ .

FIG. 8. *To make a square equal to two given squares.*

Make the perpendicular sides  $a c$  and  $a b$  of the right angled triangle  $a b c$  equal to the sides of the given squares  $A$  and  $B$ , draw the hypotenuse  $c b$ , which is the side of the square  $C$ , equal to the two squares  $A$  and  $B$ . In the same manner may a semicircle be made equal to two given semicircles, or any similar figures whatever.

FIG. 9. *To make a square equal to three given squares.*

Let  $A B C$  be the three squares; make  $a b$  equal to the side of  $B$ ,  $a c$  equal to the side of  $A$ , at right angles to  $a b$  join  $b c$ , then make  $a d$  equal to  $b c$ , make  $a e$  equal to the side of  $C$ , join  $d e$ , which will be the side of the square  $D$  equal to the squares  $A B C$ .



## P L A T E V.

FIG. 1. *To draw a segment of a circle to any length and height.*

$A b$  is the length,  $i b$  the height; divide the length  $a b$  into two parts by a perpendicular, divide  $a b$  by the same method, then their meeting at  $g$  will be the centre; fix the foot of the compasses in  $g$ , extend the other leg to  $b$ , make the arch  $a b b$ , which is the segment.

FIG. 2. *To draw a segment by rods, to any length and height.*

Get two rods  $c e$  and  $c f$ , each equal to  $a b$  the opening; place them to the height at  $c$ , and to the ends  $a b$ , put a piece across them to keep them tight, then move your laths round the points  $a b$ , and it will describe the segment at the point  $c$ .

FIG. 3. *To describe a segment of a circle at twice, upon true principles, by a flat triangle.*

Let the extent of the segment be  $a b$ , its height  $c d$ , from the extreme  $b$  to the top  $d$  draw  $b d$ , through the point  $d$  draw  $e d$  parallel to the base  $a b$ , equal in length to  $d b$ , describe one half, as you see at  $G$ ; then move your nail, or pin, out of  $a$ , stick it in the point  $b$ , and describe the other half.

FIG. 4. *The transverse and conjugate axis of an ellipsis being given, to draw its representation.*

Draw  $a d$  parallel and equal to  $n c$ , bisect it in  $e$ ; draw  $e c$  and  $d g$  cutting each other at  $m$ , join  $m c$ , bisect it by a perpendicular meeting  $c g$ , produced at  $h$ ; draw  $b d$ , cutting  $b a$  at  $k$ , and make  $n i$  equal to  $n k$ ;  $n l$  equal to  $n b$ ; through the points  $i, l, k, h$ , draw the lines  $b i, k l$ , and  $i l, h k$ , then describe the four sectors by help of the centres  $i l k h$ , and it will be the representation required.

FIG. 5. *To describe an ellipsis by ordinates.*

Make a semicircle on the length  $a b$ , divide it into any number of equal parts, as 16, on the end at  $a$ , make  $a 8$  perpendicular, equal to half the width, and draw the ordinates through all the points in the semicircle, draw the line  $8 1$  to the centre, then  $a 1 8$  will be a scale to set your oval off; take 1 1 from your scale, and set it from 1 to 1 in your oval both ways at each end; then take 1 2 in your scale, and set it to 1 2 in your oval, and find all the other points in the same manner; a curve being traced through these points will be the true ellipsis.

## P L A T E VI.

FIG. 1. *To make an ellipsis with a string.*

Take half the longest diameter  $a b$ , that is,  $a g$ , with that distance fix the foot of the compass



Plate 5.

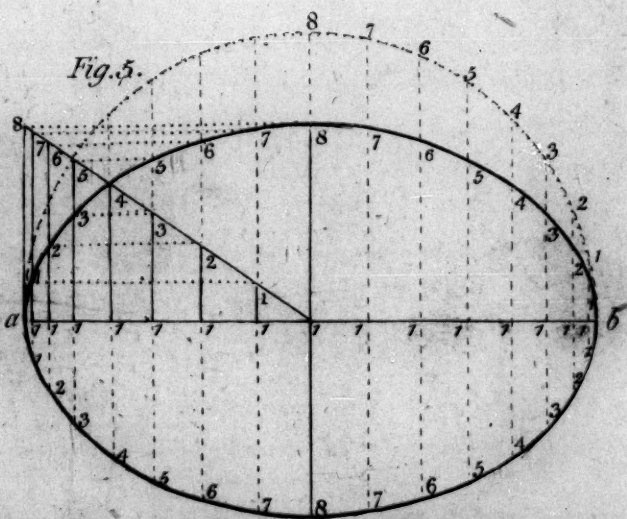
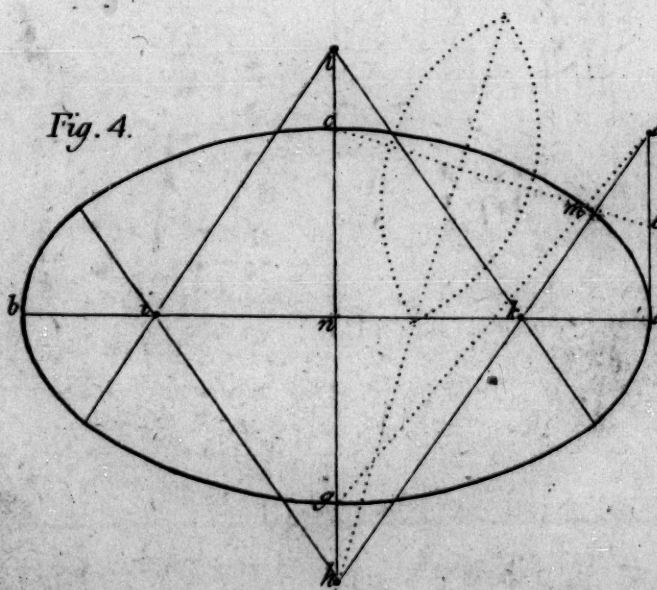
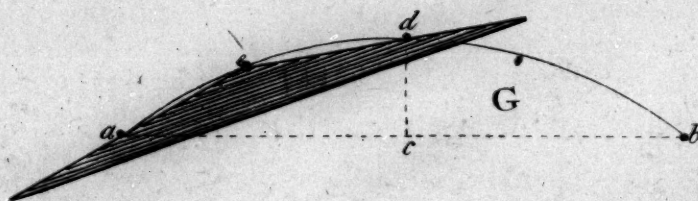
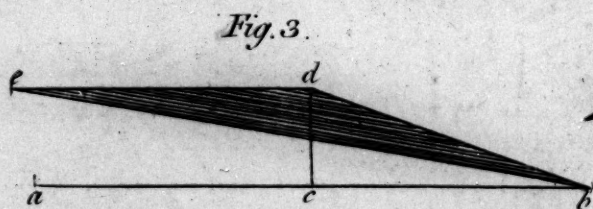
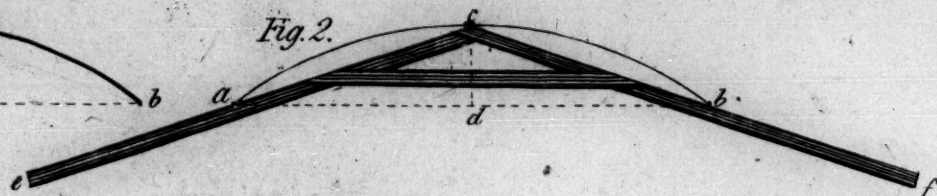
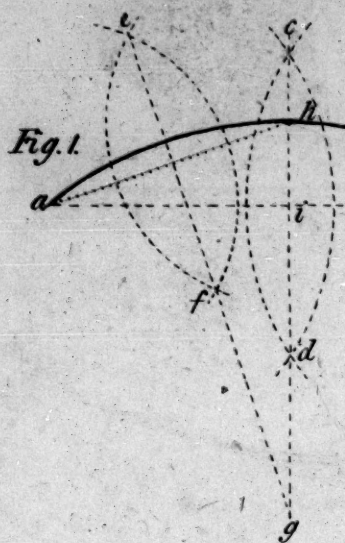




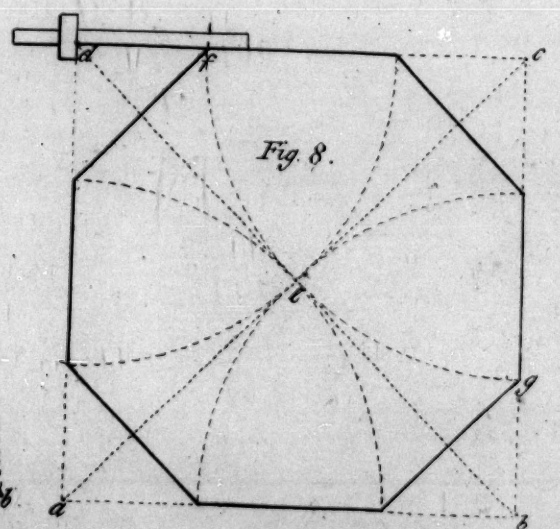
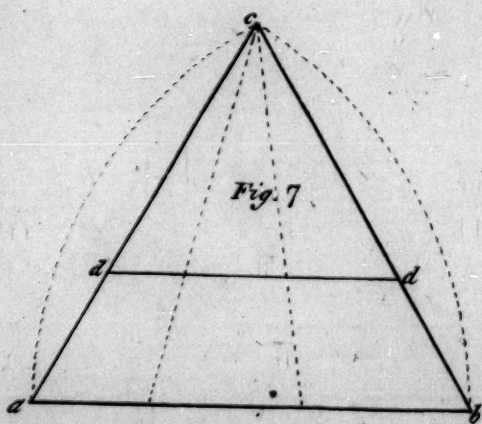
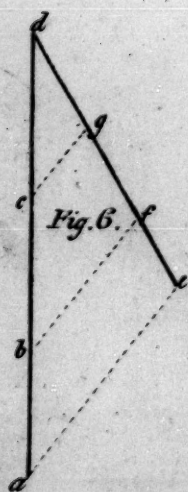
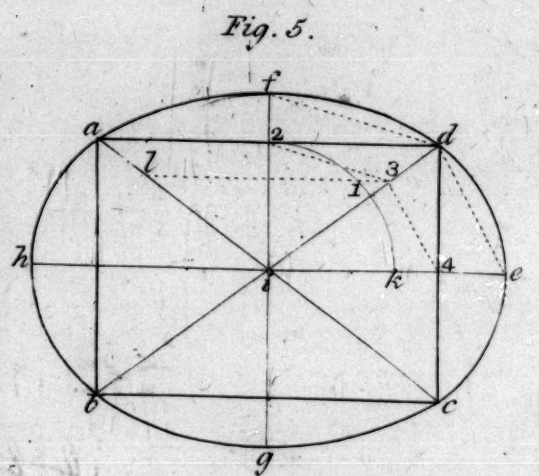
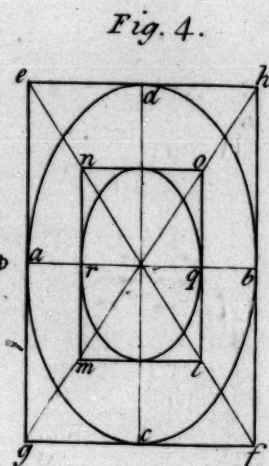
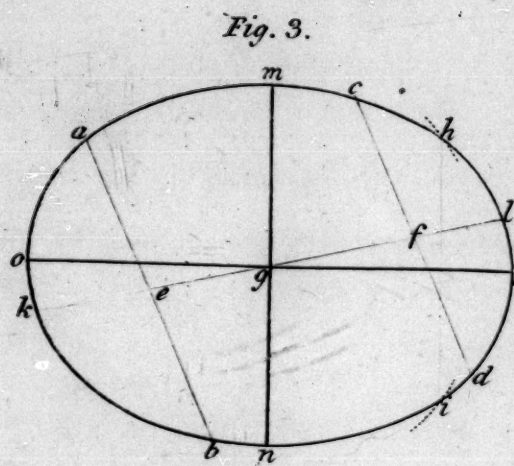
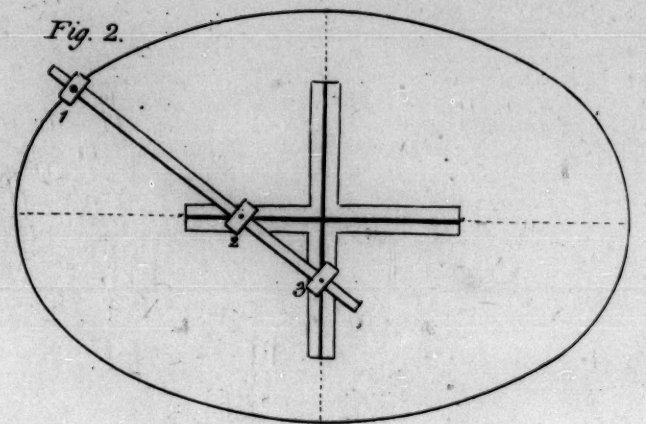
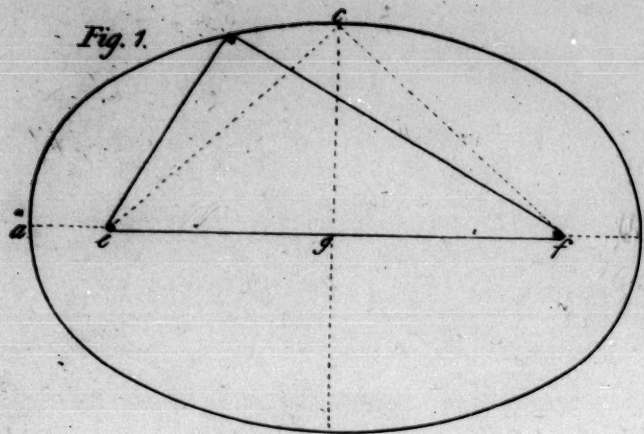








Plate 6.





compass in  $c$ , cross  $a b$  at  $e f$ , stick in two nails or brads, then lay a string at  $e f$  to come out to  $c$ , fix a pencil at  $c$ , and move your hand round, keeping the string tight, will describe the ellipsis.

FIG. 2. *To describe an ellipsis by a trammel.*

$1\ 2\ 3$  is a trammel rod, at  $1$  is a nut with a hole to hold a pencil; at  $2$  and  $3$  are two other sliding nuts; make the distance of  $2$  from  $1$ , half the shortest diameter of your ellipsis, and from the nut  $1$  to  $3$  equal to half the longest, the points  $2$  and  $3$  being put into the grooves of the same size, then move your pencil round at  $1$ , and the pencil at  $1$  will describe the true curve of an ellipsis.

FIG. 3. *An ellipsis being given, to find the centre and two axes.*

Draw any two parallel lines  $a b$  and  $c d$  at pleasure, divide each of them in two equal parts at the points  $e$  and  $f$ , and through  $e f$  draw the line  $k l$ , divide  $k l$  into two equal parts at the point  $g$ , place the foot of the compass in  $g$ , with the other foot make two crosses  $h$  and  $i$ , on the circumference draw a line  $h i$ , through  $g$  draw  $m n$  parallel to  $h i$ , also through  $g$  draw  $o p$  at right angles to  $m n$ ; then  $o p$  is the transverse axis, and  $m n$  the conjugate, and  $g$  the centre of the ellipsis.

FIG. 4. *How to proportionate one ellipsis within another; that is, to give it the same length in proportion to its width, as the length of the other has to its width.*

Let the given ellipsis be  $a d b c$ , make the parallelogram  $e h g f$ , to touch the sides and ends of the ellipsis, draw the diagonals  $e f$ , and  $g h$ , of the parallelogram, let  $r q$  be the width of the lesser ellipsis given, through the points  $q$ , or  $r$ , draw  $l o$ , or  $m n$ , parallel to the transverse axis, at the points  $m$  and  $n$ , where it cuts the diagonal, draw  $m l$  and  $n o$ , parallel to the conjugate axis, will also shew its length.

FIG. 5. *How to describe an ellipsis about a parallelogram, to have the same length in proportion to its width, as the length of the parallelogram has to its width.*

Let the given parallelogram be  $a b c a$ ; let the diagonals  $a c$ , and  $b d$ , be drawn from the centre  $i$ ; draw the quarter of a circle,  $2\ 1\ k$ , to half the width of the parallelogram; divide the quadrant into two equal parts at  $1$ ; through the point  $1$ , draw the line  $l\ 3$ , parallel to the transverse axis, to cut the diagonal  $b d$  in the point  $3$ ; then draw the lines  $3\ 2$ , and  $3\ 4$ : again, draw  $f d$ , parallel to  $2\ 3$ , then  $i f$  will be half the width, and  $d e$  parallel to  $3\ 4$ ; and  $i e$  will be half the length of the ellipsis: make  $i h$  equal to  $i e$ , and  $i g$  equal to  $i f$ , which will give the four points through which the ellipsis must pass; describe the curve, and the thing will be done.

FIG. 6. *To divide a line in the same proportion as another is divided.*

$D a$ , is a line given already divided, and  $d e$  is a line to be divided in the same proportion, making

C



making any angle at  $d$  join  $a e$ , draw  $b f$  and  $c g$ , parallel to  $a e$ ; then  $d e$ , is divided at  $f$  and  $g$ , as  $a d$  is at  $b$  and  $c$ .

FIG. 7. *To do the same by an equilateral triangle.*

$A b$  is the given divided line, take  $c d$  the length as you would have divided;  $d e$  is the same length, and is divided in the same manner as  $a b$ .

FIG. 8. *To make an octagon the nearest way in a square.*

Draw the diagonal of the square to cross at  $e$ , fix the foot of your compass in  $c$ , and make an arch  $f e g$ ; then set your gauge to  $d f$  or  $b g$ , which will gauge off each angle.

## PLATE VII.

### CONIC SECTIONS BY INTERSECTING LINES.

#### DEFINITIONS.

1. *A cone is a figure standing upon a circular base, and diminishing to a point at the top.*
2. *If a cone is cut by a plane passing through its sides, then the figure so cut is an ellipsis.*
3. *If a cone is cut by a plane parallel to one of its sides, then the figure is a parabola.*
4. *If a cone is cut by any plane passing through the opposite cone, then the figure is an hyperbola.*

*To describe the ellipsis from the cone.*

FIGURE A. Let  $B$  be half the circle of the base of the cone,  $n$  the vertex at the top; then  $n a$  and  $n d$  are two sides; let the cone be cut by a plane passing through  $g b$ ; bisect  $g b$  at the point  $k$ , and through  $k$  draw  $r q$ , parallel to the base  $a d$ ; also bisect  $r q$  in  $m$ , describe the semicircle  $r p q$ , draw  $k p$  at right angles to  $q r$ ; then is  $g b$  the length of the ellipsis, and  $b k$  half its width; then the figure may be described at  $C$ , which is explained in the next plate.

*To describe the parabola from the cone.*

FIGURE A. Let  $i e$  be the axis of the parabola, parallel to the other side  $n d$  of the cone, and through  $e$  draw  $e c$  at right angles to the base; then will  $e c$  be half the width of the parabola, and  $e i$  its height; then the figure will be described, as at  $D$ , by intersecting lines upon each ordinate, up to the crown, from the equal divisions on each side.

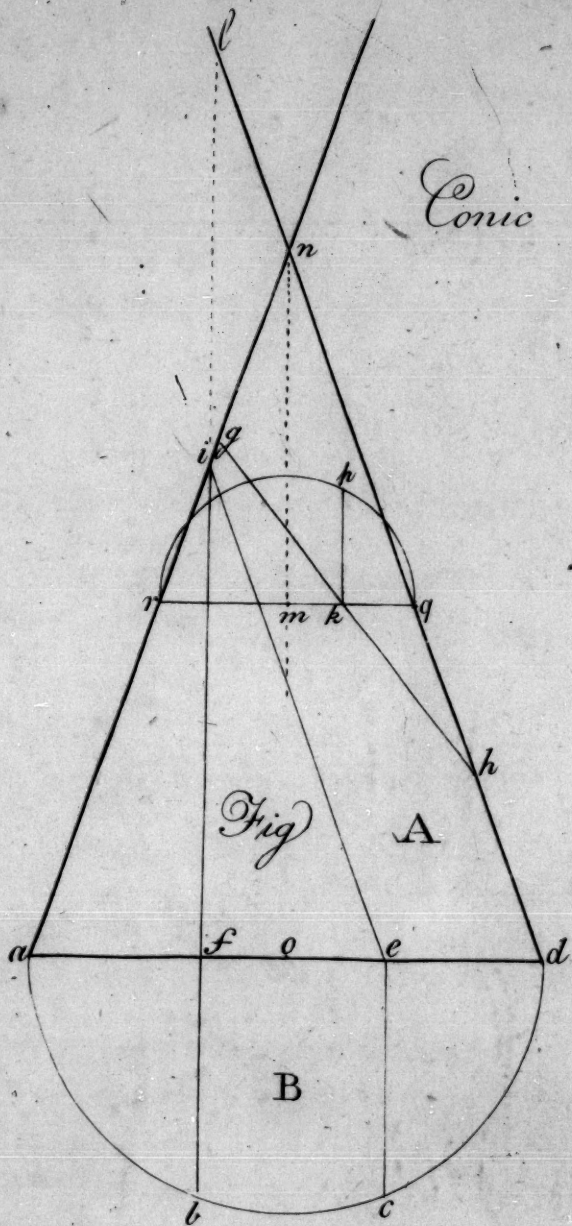
*To describe the hyperbola from the cone.*

FIGURE A. Let the axis of the hyperbola be  $i f$ , cut by a plane passing through  $f$  and  $i$ , till it cut the opposite cone at  $l$ ; draw  $f b$  at right angles to  $a b$ , then is  $f i$  the height of an

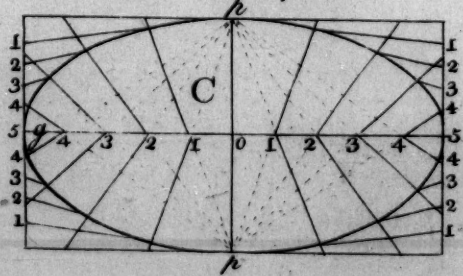


Plate 7

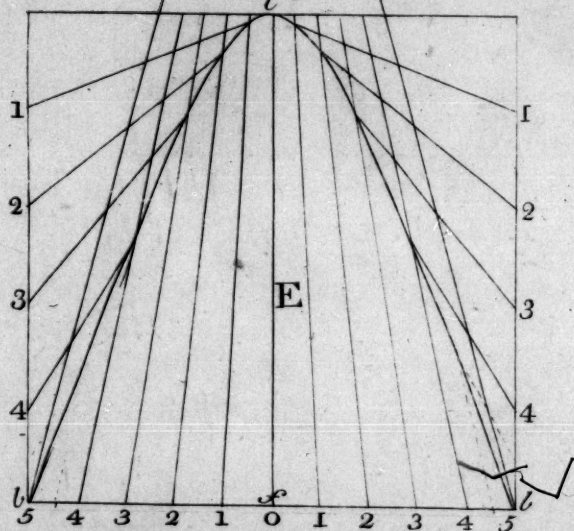
Conic Sections



The Ellipsis



The Hyperbola



The Parabola

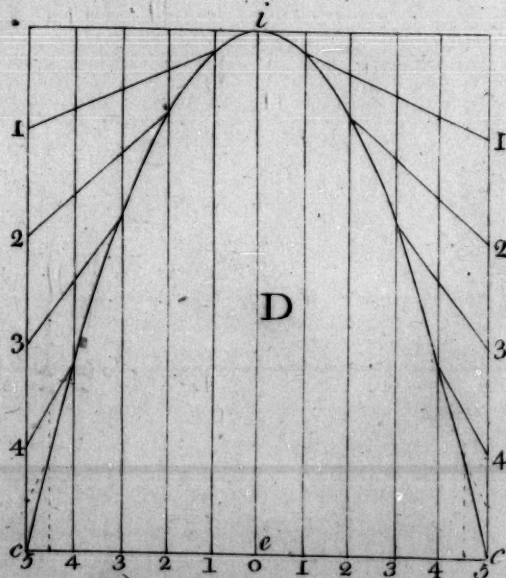












Plate 8

Fig A

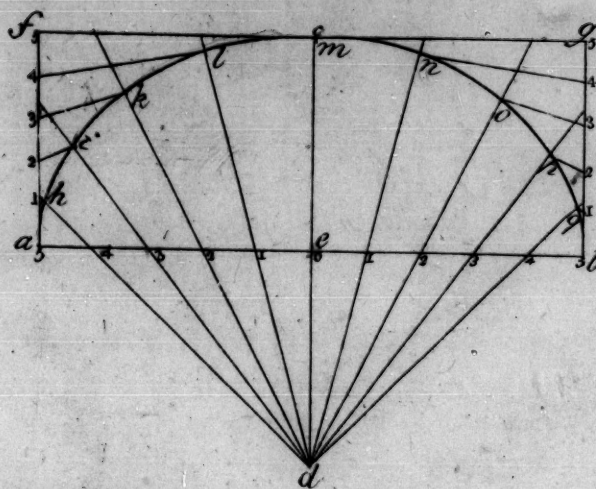


Fig B

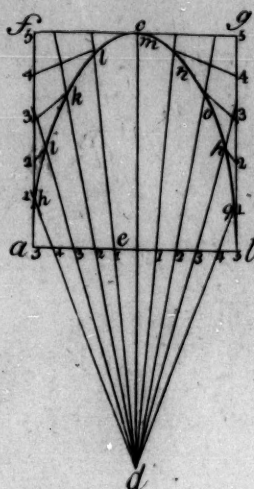


Fig C

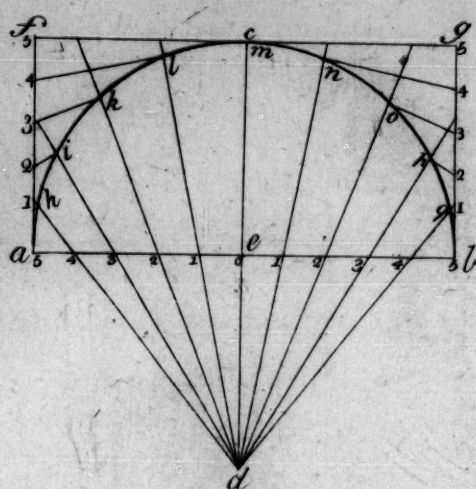


Fig D

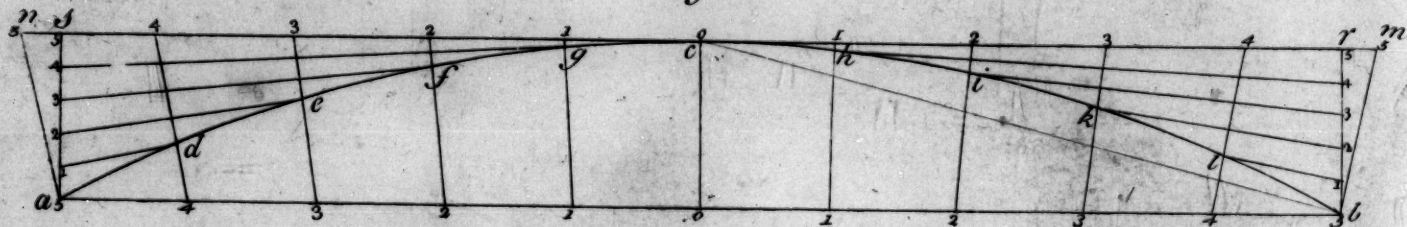


Fig E

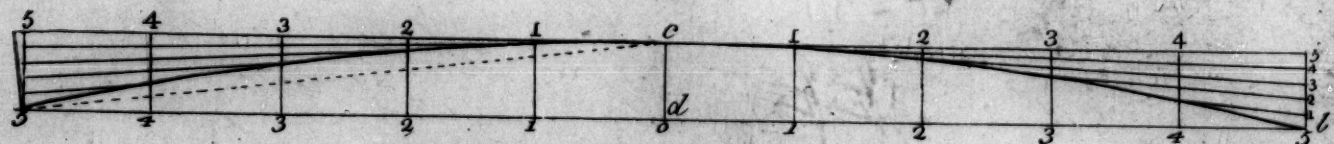


Fig. F.

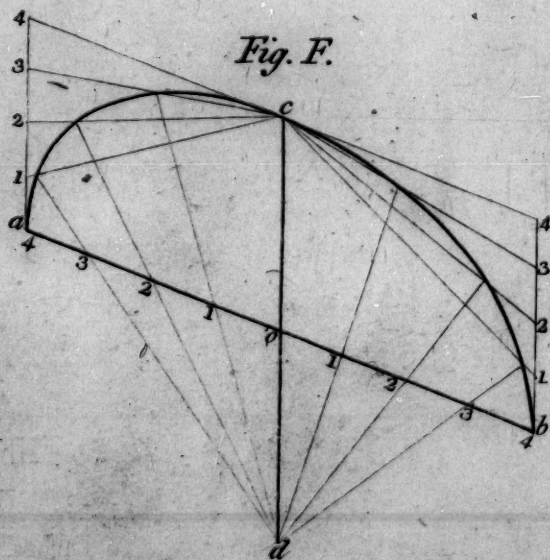


Fig. G

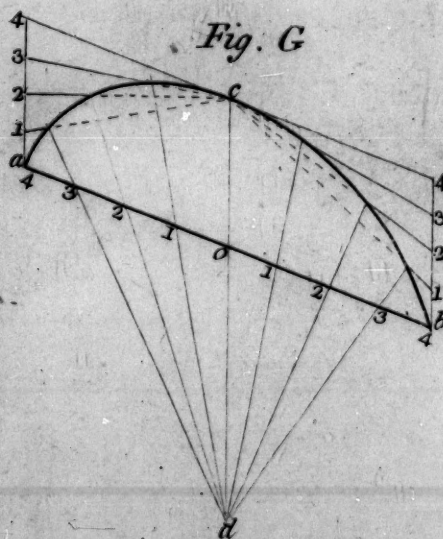
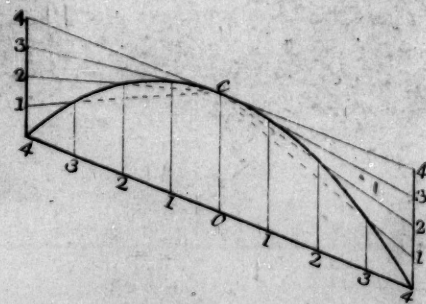


Fig. H.





an hyperbola, and  $fb$  half the width of the base, and  $il$  its transverse axis; then make  $fi$  at  $E$  equal to  $fi$  in figure  $A$ , make  $il$  in  $E$  equal to  $il$  in figure  $A$ ,  $bb$  in  $E$  equal to twice  $fb$  in figure  $A$ ; let the base  $bb$  in  $E$  be divided into ten equal parts, as at  $0\ 1\ 2\ 3\ 4\ 5$ , that is, into five equal parts on each side from the centre, and draw lines to the point  $l$  through these points; likewise divide the height into five each way, and draw lines to the crown at  $i$ ; this will shew the points through which the curve must pass.

## P L A T E VIII.

*How to draw any semi-ellipsis upon the transverse, or conjugate axis, or even a semicircle itself, by a new method of intersecting lines.*

FIGURES A and B. Let the given axis be  $ab$ , and let it be divided into any number of parts, as 10; also let the height be divided into half the number of parts; make  $ed$  equal  $ec$ , that is, to the height of the arch; then, from the point  $d$ , draw lines through the equal divisions of the axis  $ab$ ; likewise, through the points  $1\ 2\ 3\ 4\ 5$ , in the height  $af$ , draw lines tending to the crown at  $c$ , which will intersect at the points  $h\ i\ k\ l$ ; and lines being drawn through the divisions of  $bg$  to  $c$ , at the crown, in the same manner, will give the points  $n\ o\ p\ q$ ; a curve being traced through these points, will shew the true curve of an ellipsis.

The semicircle, figure C, is drawn in the same manner, by making  $af$  equal to one half of  $ab$ .

*How to draw the true segment of a circle, by the method of intersecting lines.*

FIGURE D. Let  $ab$  be the length of the segment, and  $oc$  its height, and draw the chord  $bc$  for one half of the segment, and draw  $bm$  at right angles to  $bc$ ; and from the centre at  $o$ , divide the diameter  $ab$ , each way, into five equal parts; also from  $c$ , at the crown, in the centre of the line  $mn$ , divide  $cm$ , and  $cn$ , each into five equal parts; and draw  $1\ 1, 2\ 2, 3\ 3, 4\ 4, 5\ 5$ , on each side, through the divisions  $1\ 2\ 3\ 4\ 5$  on  $as$ , and  $1\ 2\ 3\ 4\ 5$  on  $br$ ; draw lines to the crown at  $c$ , which will intersect the other lines at the points  $d\ e\ f\ g$ , and  $h\ i\ k\ l$ : the curve being traced, the thing is done.

*How to draw a flat segment of a circle nearly true.*

Divide the length of the segment into equal parts each way, from the centre  $d$ , as before, and draw the lines  $1\ 1, 2\ 2, 3\ 3, 4\ 4, 5\ 5$ , all at right angles, to the length  $ab$ ; lines being drawn to the crown at  $c$ , from the divisions at each end, will shew the points which the segment must pass through; the curve being traced, the thing is done.

*Remark.* Although this last method is not the true segment of a circle, but a parabolic curve, yet it will be found useful in practice, in tracing any segment whose height is not more than one tenth part of its length; and if the centre of the segment is found, and drawn with a compass, the difference will hardly be seen, and the flatter the segment is, this difference will become the more imperceptible; but if the height exceeds one tenth of



its length, the difference will be visible; for then the arch will be quicker at the crown, and get fatter and flatter towards each extreme.

In the same manner may all kinds of rampant ellipses be described, or any segment of them, as at *F* and *G*, also a rampant parabola in the same manner as at *H*.

### PLATE IX.

#### THE SECTIONS OF A CYLINDER.

##### DEFINITION.

*A cylinder is a figure generated by the revolution of a right angled parallelogram about one of its sides; consequently the ends of the cylinder are equal circles, and the line passing through the centre of the cylinder, is called the axis.*

*The section of a cylinder, cut by any plane, is an ellipsis. This is evident to the meanest conception; but for a farther satisfaction, it is proved by the writers of conic sections.*

*To find the section of a semi-cylinder, by ordinates, when it is cut at right angles to the plane, passing through its axis, in the direction *a b*. FIG. 1.*

Let the circle of the base be divided into equal parts at *B*, and drawn parallel up the cylinder to the line *a b*, at the points 0 1 2 3 4 5, &c. and from these points draw lines at right angles to *a b*; then *B* being pricked from *A*, as the figures direct, *B* will be the section of the cylinder.

##### DEMONSTRATION.

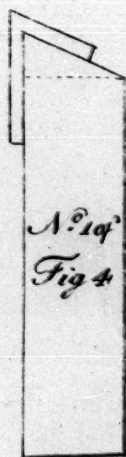
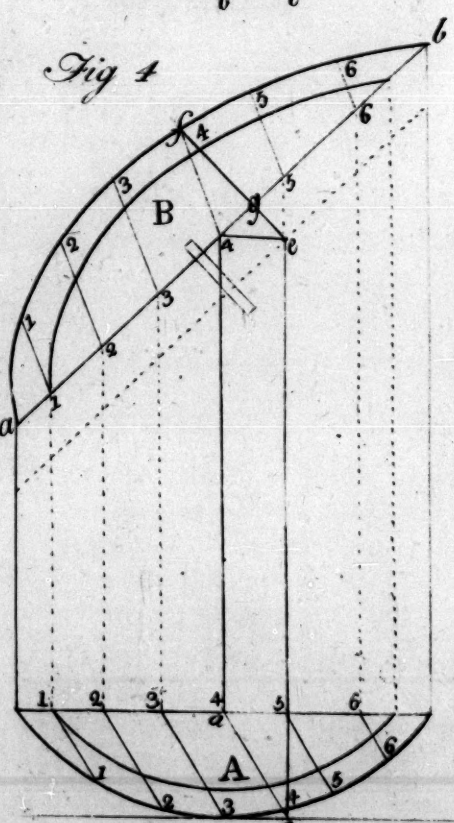
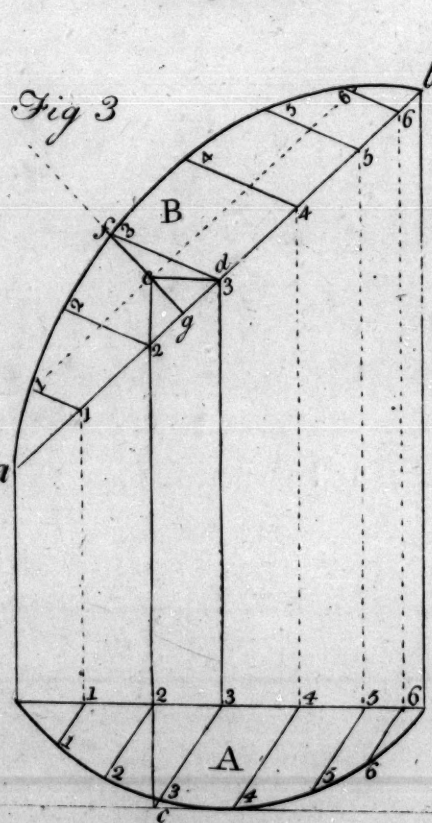
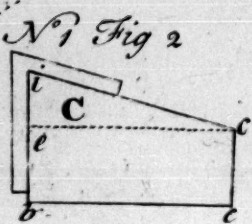
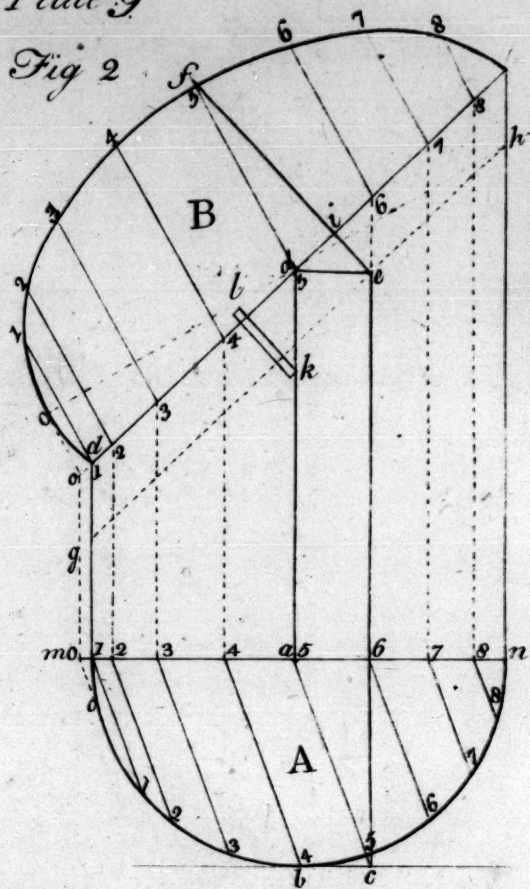
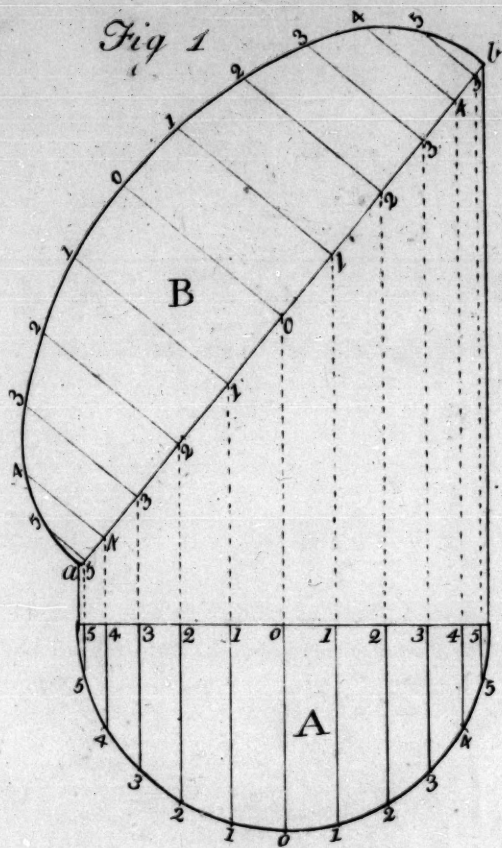
Conceive the circle *A* at the base to be turned at right angles to the plane, also the ellipsis *B* at right angles to the same plane; then will the ordinates of *B* be parallel and perpendicular over the ordinates of *A*, and every corresponding point in the circumference of *B* will fall perpendicular to the same corresponding points in *A*: therefore *B* is the true section of the cylinder, cut in this position.

*To cut a cylinder in the direction *a b*, upon a plane, passing through its axis, to make an acute angle with that plane. FIG. 2.*

Let *C*, at No. 1, be the given angle, which the section at *B* is to make with the plane of the cylinder; take *a b* in figure 2, that is, the radius of the base, and set it from *b c*, at No. 1, perpendicular to *i b*; draw *c c* parallel to *i b*, also from *c* draw *c e* perpendicular to *i b*; then take the distance *c i*, set it from *i* to *f*, in figure 2, at *B*; likewise take *i e* from No. 1, and set it from *i* to *e* in figure 2, at *B*; draw *e d* parallel to *m n*, in the base, to cut the rake in *d*, and join *d f*; then is *d f* the bevel of the first ordinate of the section *B*. And draw the lines *e c* and *d a* parallel to the axis; join *a c* at *A*; then will *a c* be the bevel of the first ordinate of the base. Then draw all the other ordinates of *A* parallel to *a c*, and at the points 1 2 3 4, &c. in *m n*, draw lines parallel to the axis of the cylinder, to cut the raking line 1 2 3 4 5, &c. From these points, let lines be drawn parallel



Plate 9









to  $df$ ; then the ordinates of  $B$ , being pricked from the same corresponding ordinates of the base at  $A$ , will give the section of the cylinder.

*Note.* The point  $f$  will fall beyond the sweep at the section  $B$ .

## DEMONSTRATION.

Since  $if$  is equal to  $ic$ , let the plane  $B$  be conceived to be turned round the line  $ab$  to make an angle at  $i$ , with the line  $ie$ , equal to  $iec$ , at No. 1; then the point  $f$  will be perpendicular to the point  $e$ , and the line joining  $e$  and  $f$ , will be equal to  $ec$ , at No. 1. But  $ec$  is equal to  $6c$  at  $A$  upon the base; therefore the point  $f$ , when opposite to  $e$ , will be perpendicular over the point  $c$ , in the base: consequently the line  $df$ , will be perpendicular, and parallel over the line joining  $ac$ ; because all the ordinates in  $B$  are drawn parallel to  $df$ , and perpendicular to every corresponding ordinate in the base, which are parallel to  $ac$ ; and as all the ordinates of  $B$  are equal to their corresponding ordinates in  $A$ , so they are also parallel and perpendicular to them; consequently every point in the circumference of  $B$ , will be over the same corresponding points in the base; therefore  $B$  is the true section of the cylinder, cut in this position, which was to be demonstrated.

*To cut a segment of a cylinder, in the direction  $ab$ , to make an obtuse angle with the plane of the segment.* FIG. 3.

Let No. 1 be the angle given, which the section  $B$  is to make, with the plane of the segment; from  $f$  in No. 1, draw  $fg$  at right angles to  $fc$ , and  $ge$  also perpendicular, to make the right angled triangle  $egf$ . And in figure 3, at  $B$ , draw  $gf$ , at right angles to  $ab$ , and make  $ge$  equal to  $ge$  at No. 1. Also, make  $gf$  at  $B$  equal to  $ef$  at No. 1. Draw  $ed$  at  $B$ , parallel to  $mn$  at  $A$ , the base, and at the point  $d$ , where it intersects the line  $ab$ , join  $df$ ; then  $df$  is one of the ordinates. From  $e$  and  $d$ , draw the two parallel lines  $ec$ , and  $d3$ , join  $c3$ ; then  $c3$  will also be an ordinate of the base. Draw parallel lines at discretion to  $c3$ , for the other ordinates of the base; and from their intersection upon  $mn$ , draw lines parallel upon the cylinder, to cut  $ab$  in 1 2 3 4, &c. and from these points, draw parallel lines to  $df$ , which are the ordinates of  $B$ : these, being pricked from the base as the figures direct, will give the points through which the curve must pass, which being traced, will be the true section of the segment of the cylinder.

## DEMONSTRATION.

Let the section  $B$  be turned round the line  $ab$ , to make an angle with the plane of the segment equal to No. 1; then,  $gf$  at  $B$  being equal to  $ef$  at No. 1, and  $eg$  at  $B$  equal to  $eg$  at No. 1, therefore a line joining  $e$  and  $f$  at  $B$  is equal to  $fg$ , or  $eb$  at No. 1, that is, equal to  $2c$ , the width of the base  $A$ ; but  $ef$  is also parallel and perpendicular over  $2c$ , therefore the point  $f$  will be perpendicular to the point  $c$  in the base: but the point  $d$  is level with the point  $e$ , that is to say,  $ed$  is parallel to  $mn$ ; and the point  $f$  becomes also level with the point  $e$ , when turned round; therefore the line joining  $f$  and  $d$ , will be parallel to the base, and perpendicular over  $3c$ : for  $d$  is perpendicular to  $3$ , and  $f$  is perpendicular over  $c$ ; consequently  $df$  is an ordinate of the section, and  $3c$  an ordinate of the base: but all the ordinates parallel to  $df$ , are respectively equal and perpendicular over those of  $A$ , which are parallel to  $3c$ ; therefore they are in the true curve of the section  $B$ , which was to be demonstrated.

That the Reader may perceive this more clear, the best way is to draw those lines on pasteboard, the section and the end being made to turn round, in their proper position; then the demonstration will be clearly seen.

FIGURE 4, is to be laid down and demonstrated in the same manner as FIGURE 2.

*Remark.*



*Remark.* Upon these figures depend the whole principles of hand rails for stairs: the Reader ought to understand how to form the section of a cylinder, in any case whatever; for the face or raking mould of a hand rail is nothing but the double section of a cylinder, as in *figure 4*, at *B*, where the double circle upon the base *A* represents the plan of a rail, and the bevel at No. 1, *figure 4*, represents the spring of the plank, and *a b* the pitch of the rail: therefore, it is very necessary that the Reader ought to have a knowledge of these figures and their demonstrations; and not to be satisfied with only doing of it, but to read these demonstrations, and consider them with attention; then he will be able to see the reason why every line is drawn in the manner it is.

### PLATE X.

THE SECTIONS OF A GLOBE, OR ANY OTHER FIGURE STANDING UPON A CIRCULAR BASE; ALSO, THE SECTION OF ANY FIGURE STANDING ON AN IRREGULAR BASE.

#### DEFINITION.

*A globe is a figure generated by the revolution of a semicircle round its diameter, which becomes the axis of the globe.*

#### AXIOMS; OR, SELF-EVIDENT TRUTHS.

- 1st. *From this definition it appears, that every plane section passing through the centre, is equal to one another.*
- 2d. *Every section of a globe, cut by a plane, is a circle; for the generating circle may be made to revolve round any line, as an axis; and therefore every point in it will generate a circle, whose diameter must be twice the radius of that circle, distant from the axis of the globe.*
- 3d. *If a semi-globe is cut by a plane at right angles to the plane of its base, the section will be a semicircle.*

*To find the section of a semi-globe cut by a plane at right angles to the plane of its base. FIG. 1.*

It appears from the last axiom, that there is no tracing required: for, let the section be cut across *a b*, *figure 1*; divide *a b* in two equal parts at the point *c*; and on *c*, as a centre with the radius, *c a*, or *c b*, describe the semicircle *A*, which is the true section required.

*The same by ordinates. FIG. 2.*

Draw any line *d e* through its centre, and let *a b* be the place of the section upon the base, as before; place the foot of your compass in the centre of the globe at *f*, and, with a radius *f c*, draw an arch from *c*, round to *g*, in the diameter *d e*; the foot of your compass remaining still in *f*, draw the concentric dotted circles from *c b* to *f e*, and at the intersecting points



Plate 10

Fig 1

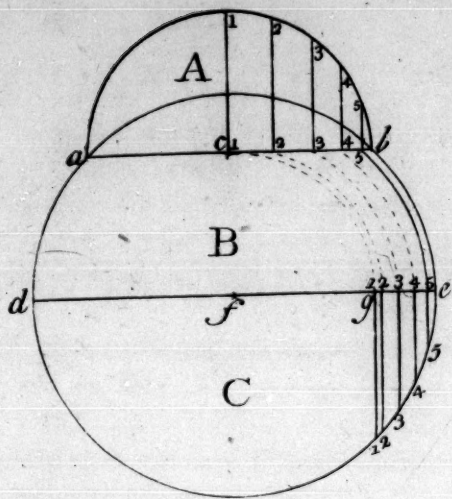


Fig 2

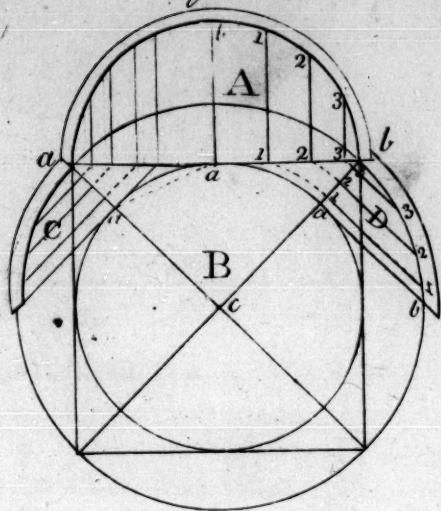


Fig 3

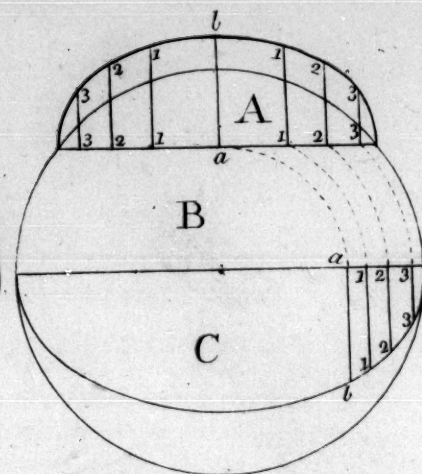


Fig 4

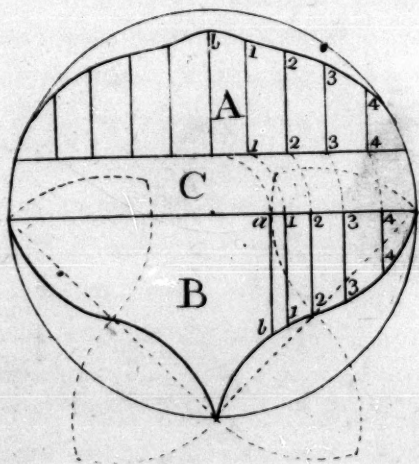
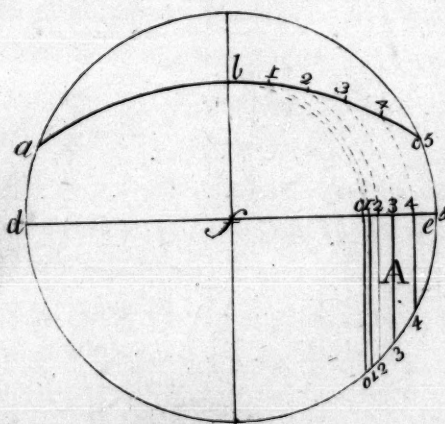
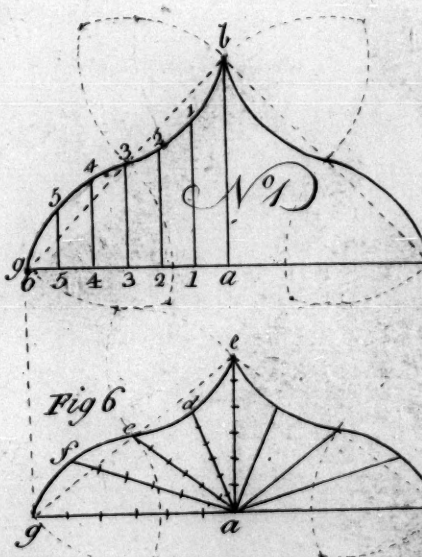
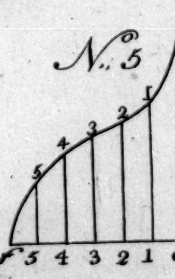
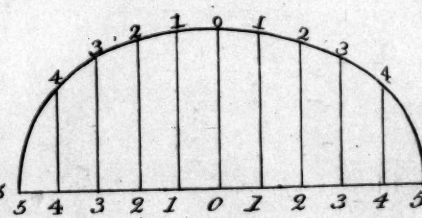


Fig 5



N<sup>o</sup> 1









points 1 2 3 4 5 in  $f e$ , and likewise in  $c b$ , erect perpendiculars to those lines; then  $A$  being pricked from  $C$ , as the figures direct, will give the points through which this semicircle must pass.

## DEMONSTRATION.

Conceive the semicircle  $C$  to stand at right angles upon  $d e$ , also the section  $A$  to be at right angles to  $a b$ ; now it is evident, if  $g i$  is the height of the globe over the point  $g$  in the base,  $c i$ , which is equal to  $g i$ , must also be the height of the section, because the points  $c$  and  $g$  stand at an equal distance from the centre; and therefore the point  $i$  over  $c$ , is in the surface of the globe. In the same manner it may be proved, that any other points carried round by the dotted lines are in the same surface; but the section that stands upon  $a b$ , in  $A$ , is a semicircle; and consequently the method of tracing is also a semicircle.

*Observation.* Hence appears the erroneous principle of tracing used by a late writer upon this subject, as you may see at *figure 2*, where  $A$  is the section of a globe, and the bracket at  $D$  is the section across the diameter.  $A$  is truly traced from  $D$ , because the ordinates are carried round in circles; but by his method of tracing, as you see at  $C$ , upon the other side, the point of the bracket  $C$  falls within the sweep of the circle, by reason of the ordinates of  $C$  being carried straight through between the two bases, which I have proved to be false. And this he has applied in bracketing up the angles in the square well-hole of a staircase, to the circular curb of a skylight, which, if truly done, is nothing else but upon the same principle as the sections of a globe.

FIGURE 3, is done upon the same principle as *figure 1*.  $A$  is the section traced from  $C$ , and wants no other demonstration than what has been given in *figure 1*.

FIGURE 4, is an ogee section, standing upon a circular base across the diameter; and  $A$  is the section traced from it, upon the same principle as *figure 1*.

From these examples it is clear that this method of tracing does not depend on the form of the top, but entirely upon the base. These figures are supposed to be generated round an axis; and, as every circle is carried round at an equal distance from the axis, the perpendicular height of the figure, upon any circle, must be the same height in every point throughout that circle; which proves itself to be the only method for any thing of this kind.

*A semi-globe being cut by a cylindrical surface perpendicular to the plane of its base, to find the form of a veneer that will bend round it. FIG. 5.*

Let  $d e$  be drawn through the centre  $f$ ; and place the foot of your compass in  $f$ , the centre; and from the points  $b$  1 2 3 4, which are equally divided from the centre at  $b$  in the circular surface, draw the concentric dotted lines round to the diameter  $d e$ , at  $o$  1 2 3 4, and at these points raise the perpendiculars  $o o$ , 1 1, 2 2, 3 3, 4 4. Take the stretchout round  $b$  1 2 3 4 5, which is one half; and lay it upon the base of No. 1 each way, from  $o$  1 2 3 4, &c. and No. 1 being pricked from  $A$ , *figure 5*, as the figures direct, will give the points through which the curve must pass for the veneer.

DEMON.



## DEMONSTRATION.

For, since the section standing upon  $de$  is a semicircle, which is equal to the semicircle upon the base; and as the points 1 2 3 4 in the circular surface, stand at the same distance from the centre  $f$ , as 0 1 2 3 4, in  $de$ ; now if the point 0 at No. 1, is made to coincide with the point  $b$  in figure 5, then the height  $oo$ , standing over the point  $b$ , will be equal to the height  $oo$  at  $A$ ; but these points are at an equal distance from the centre, therefore the top of each ordinate will be in the surface of the globe. In the same manner every other point may be proved, when bent round and elevated, to be of the same height, and at an equal distance from the centre with those of  $A$ ; and therefore No. 1 is the true form of the veneer.

*To find the ribs of a gothic niche, being the plan, and No. 1 the front elevation. FIG. 6.*

Take the length of each base upon the plan, and make them the bases of No. 2, No. 3, No. 4, and No. 5; divide each base into five equal parts; also divide the half of No. 1 into six parts, and draw the ordinates from the equal divisions, perpendicular to each base; then prick each from No. 1, as the figures direct, will give the form of each rib. This wants no demonstration.



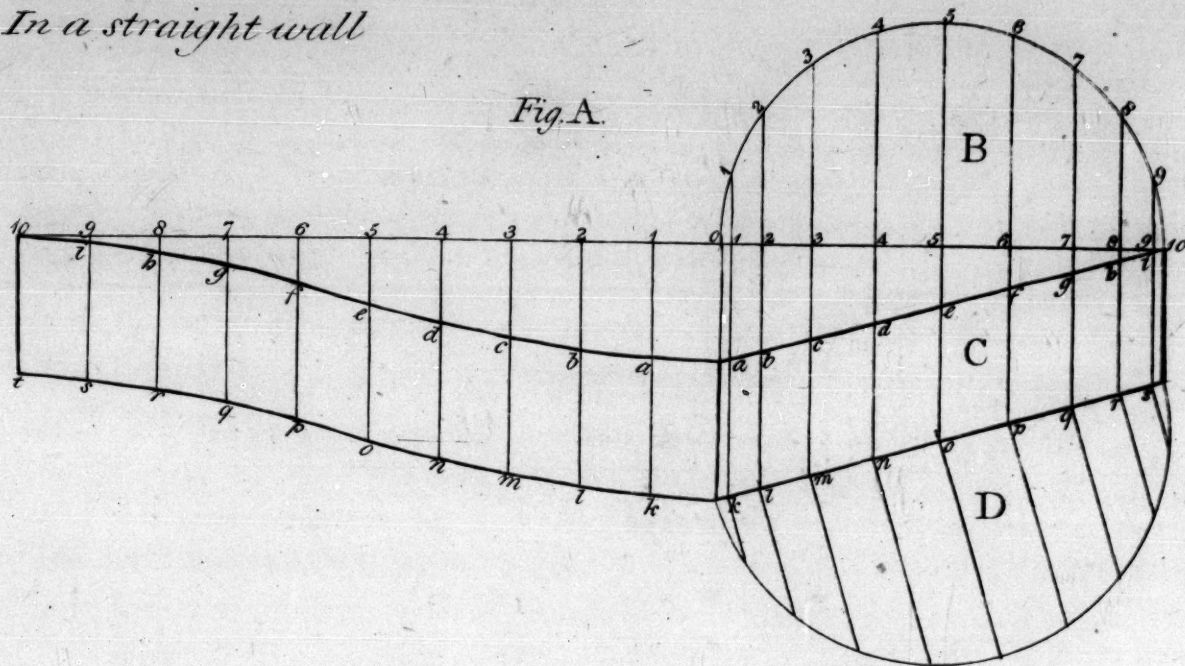




Plate 11

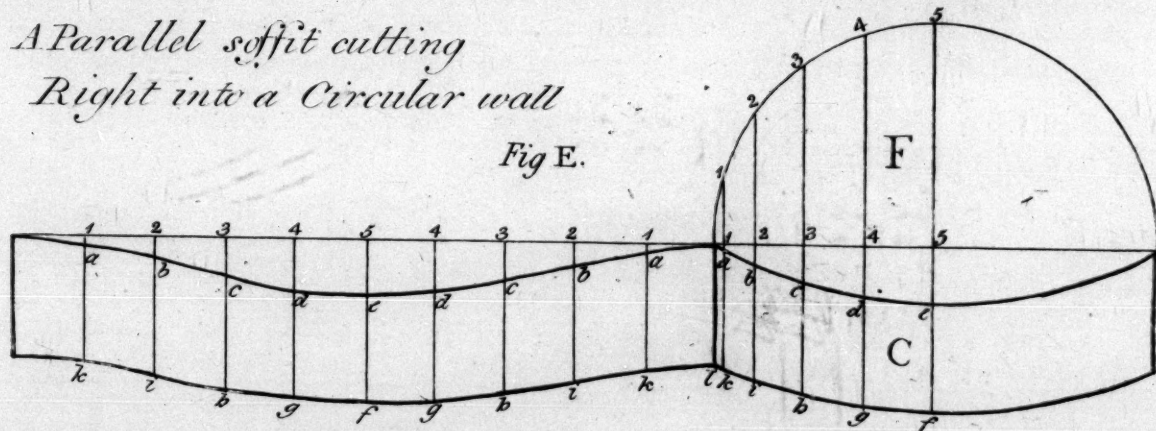
A Parallel soffit cutting oblique  
In a straight wall

Fig. A.



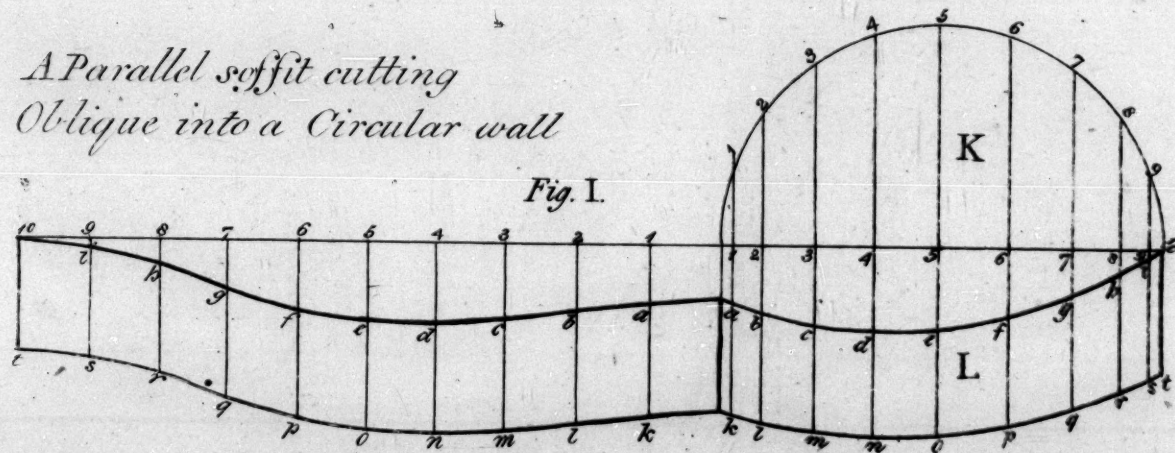
A Parallel soffit cutting  
Right into a Circular wall

Fig. E.



A Parallel soffit cutting  
Oblique into a Circular wall

Fig. I.





THE  
THEORY AND PRACTICE  
OF  
CARPENTRY.

---

PLATE XI.

DEFINITION.

*A soffit, in the Theory of Carpentry, signifies the covering of any surface whatever, spread out on a plane if possible.*

---

*How to stretch out a soffit, when a window or door, having a semicircular head, cuts into a straight wall, in an oblique direction.*

Let *C* be the plan or opening of the window, in *fig. A*, and let the base of the semicircle *B* be drawn at right angles to the jambs, or sides of the plan *C*; divide the semicircle into any number of equal parts, as ten, and draw the ordinates across the plan *C*, then stretch the divisions round *B*, along the soffit, in the same straight line with the base of *B*; under *fig. A*, the ordinates being drawn across, and traced off from the plan *C*, as the figures and letters direct, the soffit will then be completed.

If you would make a cylinder to be only the thickness of the wall, *D* shews the end of it, which is to be traced from the semicircle *B*.

*How to draw a soffit when the top is a semicircle, cutting right into a circular wall.*

FIG. *E*. This and the other below are performed the same as that above, with this difference, that you are to prick from the circular plan, instead of the straight plan.

FIG. *I*. shews the method when a circular headed window cuts oblique into a circular wall.

*Note.* In all kind of soffits, when the two jambs are parallel, the straight line, which the soffit is pricked from, must be drawn at right angles to the jambs, as is shewn in this plate; for want of this consideration, they are shewn in books upon wrong principles.

But in the following soffits, where the jambs are not parallel, they must be continued till they meet in a point, and the line which the soffit is to be pricked from must be made to form an isosceles triangle with the jambs.



## P L A T E XII.

*To draw a soffit in a straight wall, fluing equally all round with a circular head.*

In *fig. A*, continue the sides of the plan *A*, that is *a c* and *b d*, to meet at *e*; then about the centre *e*, and from the points *a* and *c*, describe the soffit *C*, and stretch the semicircle *B* along the outline of the soffit *C*, it will be completed.

*To draw a soffit in a circular wall, fluing equally all round with a circular head.*

FIG. B. The stretch out of this soffit is managed the same as in the last; draw the ordinates of the semicircle *B*, from thence continue them to *f*, the centre of the flue, and at the points *a b c d e*, where they intersect the plan, draw the parallel lines *a e*, *b f*, *c g*, &c. and from the points *e f g h* and *i*, circle lines to *a b c d* and *e* round the centre *f*, which will give the half of one edge of the soffit, the other half being pricked from it; the other edge is found in the same manner.

*Note.* This cannot be pricked from the plan as the others are, as the lines round the flue are not level with the plan, and will be longer than those on the plan.

## D E M O N S T R A T I O N O F FIG. A.

Conceive the semicircle *B* to be turned at right angles to the plan *A*, then every point in the circumference of the semicircle *B* will be at an equal distance from the point *e*, but the soffit *C* is described with the same radius; therefore the edge of the soffit *C*, that is the arch line *a f*, will exactly coincide with the arch of the semicircle *B*, which was to be proved.

## D E M O N S T R A T I O N O F FIG. B.

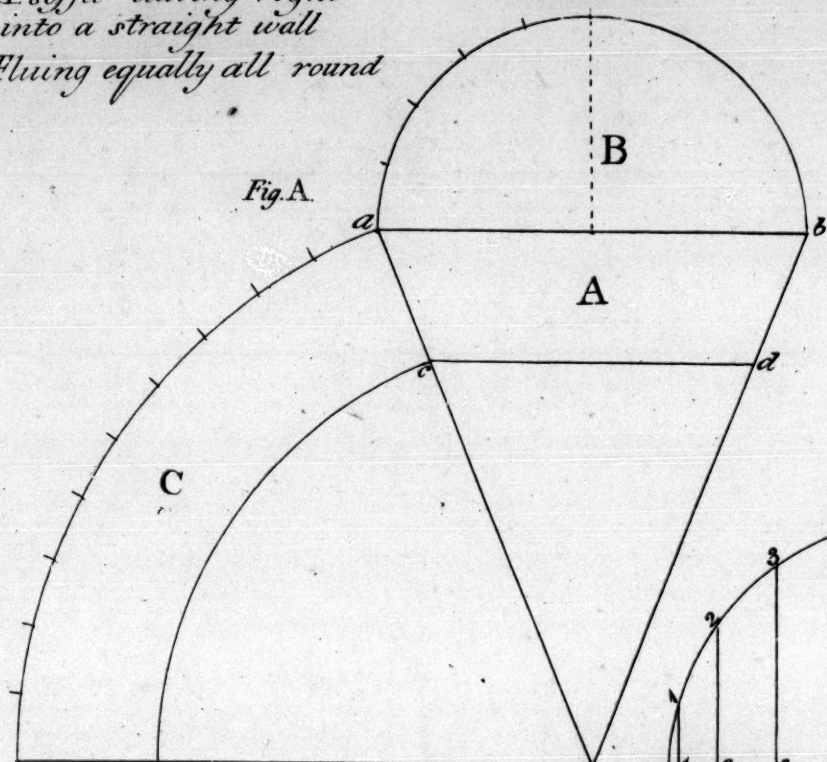
It is easy to conceive from the last demonstration, that if the semicircle *B* is turned up, and the soffit at *C* bent round it, the points 1 2 3 4 5 at *C* will coincide with the equal divisions in the semicircle *B*, and the points *a b c d*, &c. at *C*, will fall perpendicularly over the points *a b c d*, &c. in the plan *A*; for the arches *a e*, *b f*, *c g*, *d h*, and *e i* at *C* will fall over the parallel straight lines *e a*, *f b*, *g c*, *h d*, *i e*, in the plan *A*, which was to be demonstrated.

The learner is advised to cut these and the following soffits out of pasteboard, and their demonstrations will be more clearly seen.

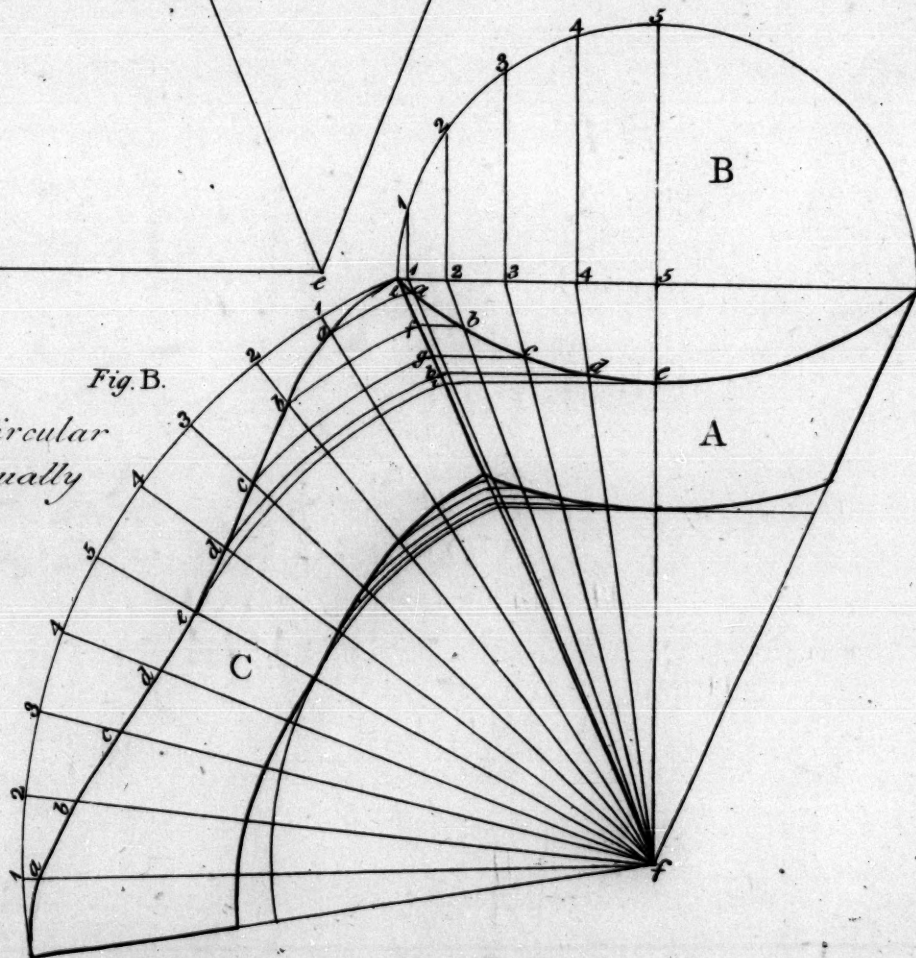


Plate 12

*A soffit cutting right  
into a straight wall  
Fluing equally all round*



*A soffit in a Circular  
Wall fluing equally  
all round*



*Pub<sup>d</sup> as the Act directs Aug<sup>r</sup> 1793 by P. Nicholson.*





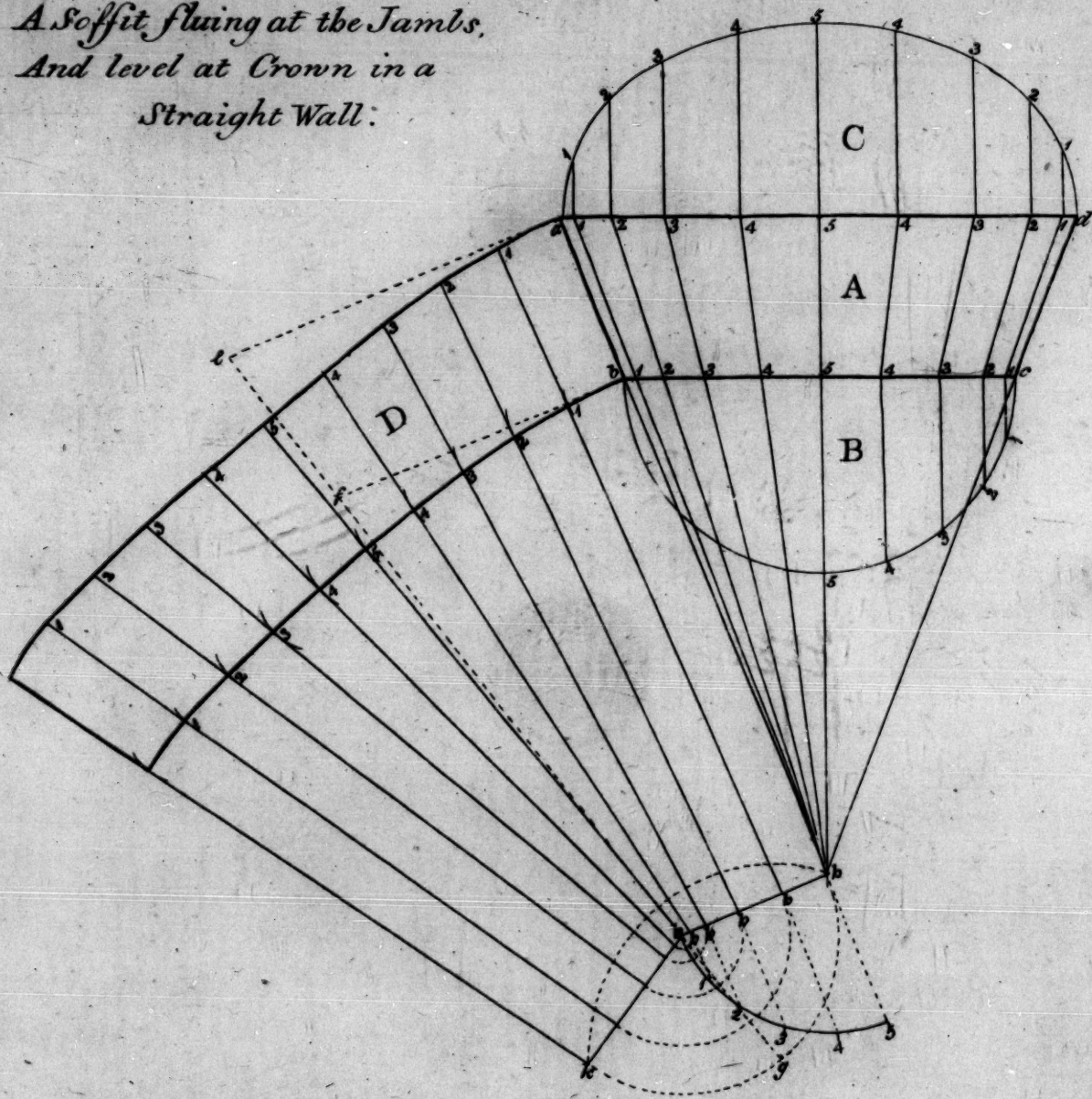






Plate 13.

*A Soffit fluing at the Jambs,  
And level at Crown in a  
Straight Wall:*



*Pub.<sup>d</sup> as the directs Aug.<sup>o</sup> 1792 by P. Nicholson*

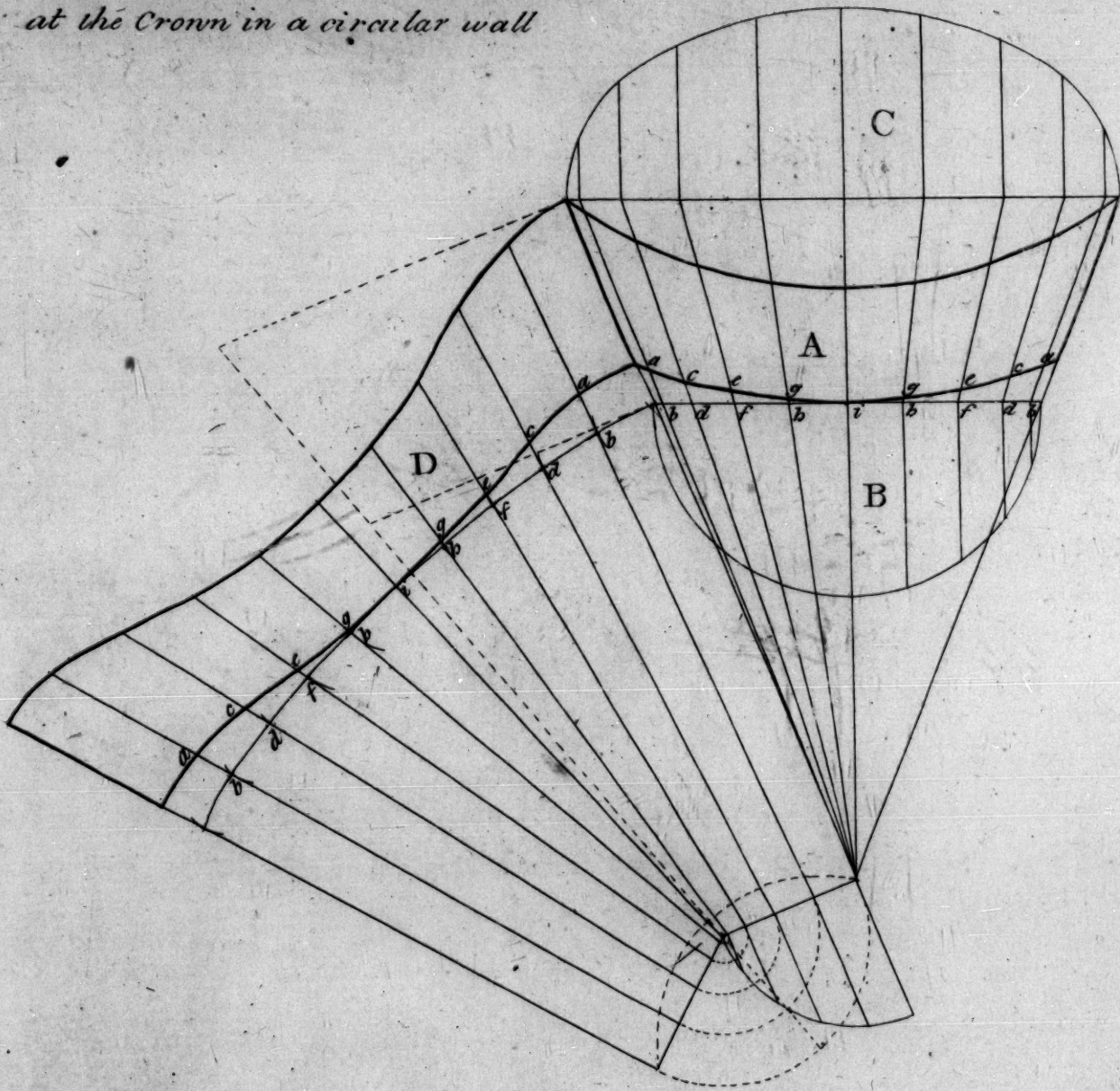






Plate 14

A soffit fluing at the Jambs and level  
at the Crown in a circular wall





## P L A T E XIII.

*How to draw a soffit in a straight wall, fluing from the jambs, and level at the crown.*

*A* is the plan of the wall, *B* is a semicircle on the outside, and *C* is an ellipsis in the inside, traced from *B*, or got by a trammel; draw the lines *a e*, *b f*, and *b h*, all perpendicular to *a b* the side of the flue of *A*; then take half the compass of *B*, and lay it on *b f* in *D*; likewise take half the compass of *C*, and lay it from *a* to *c* in *D*, and through the points *e* and *f* draw a line to cut the line *b h h*, &c. in *h*, and continue it to *g*; put your compass in the centre of the flue at *b*, and with the other extreme point describe the quadrant 1 2 3 4 5, which is divided into five equal parts, and draw ordinates 5 *b*, 4 *b*, 3 *b*, &c. then take one of the divisions of the semicircle *B*, and set the foot in *b*, and make the small arch at 1, and take *b 1* from the centre of the flue in *A*; then put the foot of your compass in *b*, in the soffit, and with the other foot cross the small arch at 1; and with the aforesaid division of *B*, set the foot of your compass in 1 in the soffit *D*, and describe the small arch at 2; and take *b 2* from the centre of the flue, and set that to its correspondent *b 2* in *D*, and by this means you will get one half of your soffit; put the foot of your compass in *b*, and with the other extreme *h* draw a circle *h g k*, and put the foot of your compass in *g*, and with the distance *g h*, that is from *g* to *h* the centre of the flue, describe an arch from *h* round to *k*, and draw the line *b k* where these two arches intersect; then set the divisions of *b h h*, &c. on *b k*, and describe the other half in the same manner, and so the out-line of the soffit will be completed.

The inside line is got by pricking it from the plan according to the figures.

## P L A T E XIV.

*To draw a soffit in a circular wall, fluing from the jambs and level at the crown.*

Proceed as in the last plate and get the line *b d f h i*, then prick the soffit *D* from the plan *A*, according to the letters.

In the same manner may any other soffit, fluing from the jambs and level at the crown, be drawn, let the form of the wall be what it will, by getting the line *b d f h i* first; then the soffit may be pricked from the plan whatever may be its form.



## P L A T E XV.

*To draw a cylindrical soffit, cutting right in a wall which does not stand perpendicular to the ground, to a level base. FIG. A.*

Let  $a e$  at  $D$  be the level of the ground,  $a l$  the inclination of the wall, equal to the radius of the cylinder, let fall the perpendicular from  $l$  to  $c$ , in the bottom line  $a e$  make the semicircle in *fig. A*; to the width of the cylinder, or the double of  $a l$  at  $D$ , take the distance  $a c$  at  $D$ , and make  $a b$  equal to it in *fig. A*, and describe a semi-ellipsis to the length of the semicircles  $d d$ , and to  $a b$  its width; lay the equal divisions round the semicircle in *fig. A*, along the line  $d d$  double at  $C$ , then take the parts  $e d, d c, c b, b a$ , from the plan  $B$ , and lay them at  $D$  respectively from  $e$  towards  $d c b$ , and from  $l$  draw  $l e$  to make a right angle with  $l a$ , and at the points  $a b c d$  erect perpendiculars to  $a e$  to cut  $l e$  at  $f g h$  and  $i$ , take the distances  $e i, i h, h g$ , and  $g f$ , and lay them on the soffit at  $C$  respectively, from 1  $d, 2 c, 3 b, 4 a$ , each way, then will the straight line  $d d$  in the soffit, when bent round, be perpendicular over the elliptic line in the plan  $B$ , and the curve line  $d d c b a$ , &c.  $d$  will fall over the points  $d c b a$  in the plan: in the same manner the edge of the soffit may be brought to answer any curve line proposed.

*To draw the arches of groins by a new method, whether right or rampant, so that their arches shall intersect or mitre truly together, from a given arch of any form.*

Let *fig. E* be the given arch of a gothic form, draw the chord  $a c$  for one half the arch, divide it into any number of parts, as 4, and through the equal divisions draw lines from the centre  $e$  to terminate in the circumference at  $b g l$ , draw lines from  $c$  through  $b g l$  to cut the perpendicular  $a d$  at  $b, c, d$ ; and if No. 2 is required to be wider, but the same height as *fig. E*, draw the two chords  $a c$  and  $c b$  for each side of the arch, divide each into four equal parts, as before, and set the divisions  $a, b, c, d$ , perpendicular on each end of  $a b$  at No. 2, and from these divisions draw lines to the crown at  $c$ , then trace the curve through the points  $b g l$ , &c. so the arch at No. 2. will truly mitre into *fig. E*; in the same manner the rampant curve at No. 3, will be brought to correspond with *fig. E* and No. 2\*.

\* Nothing can be more ready than this in practice, because a chalk line will soon strike all the radial lines, having only to move it but once from the point  $e$  up to  $c$  at the crown; *fig. F* shews the common method by dividing the basis of each into a like number of parts, and transferring the height, as the figures explain, at No. 1, and No. 2; nothing is more tedious in practice than raising a number of large perpendiculars, and going continually from one curve to get the height of another.



Plate 15

Fig A

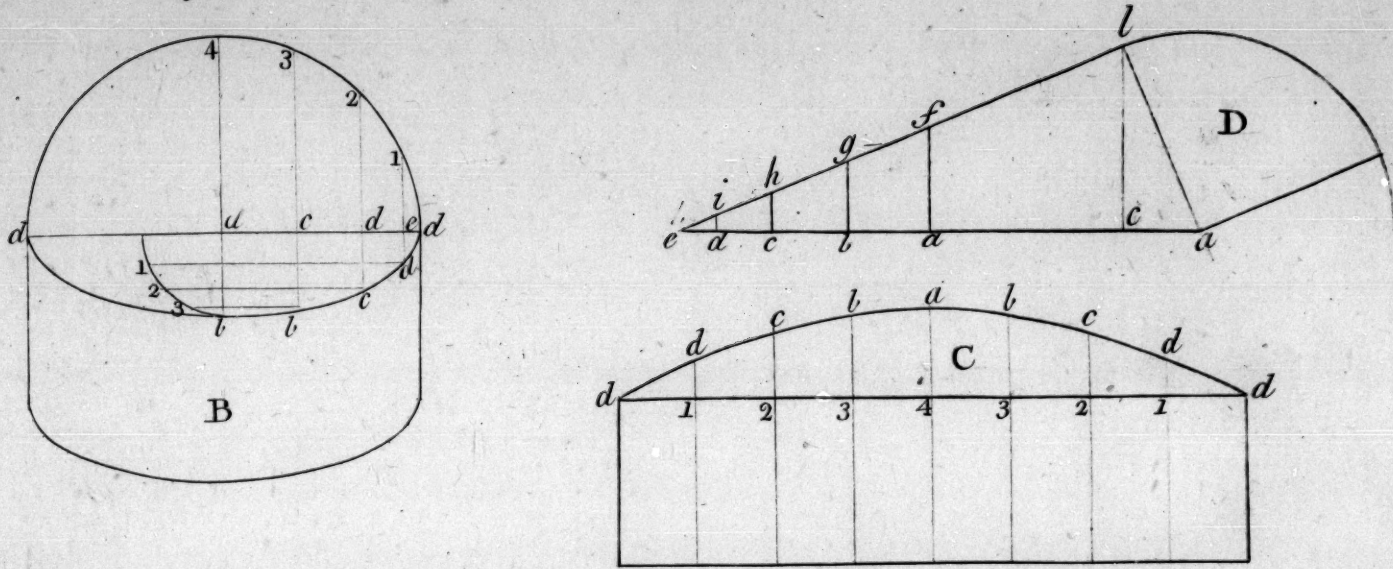
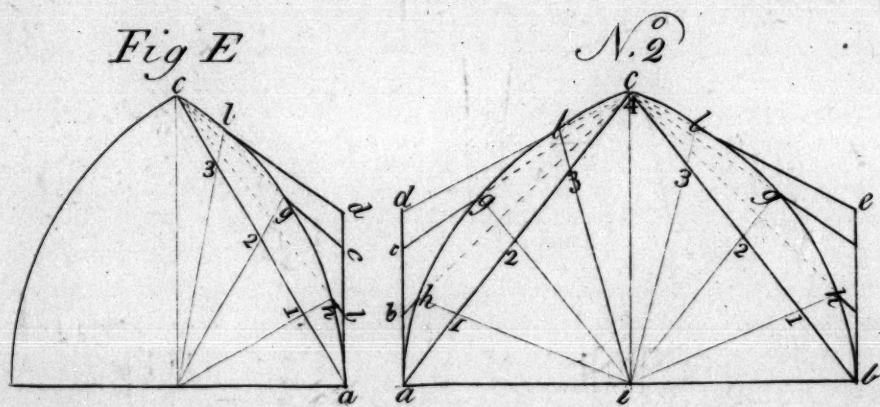


Fig E



N. 2

N. 3

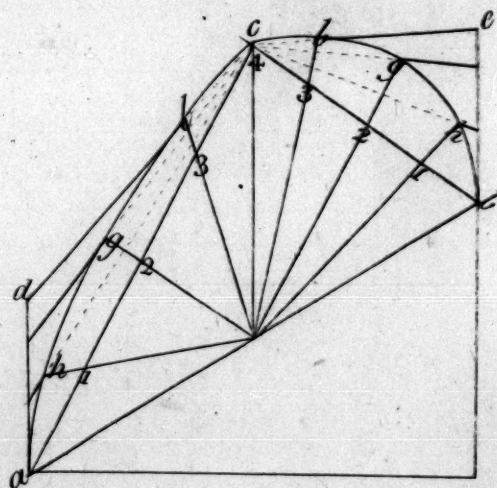


Fig F

Fig F N. 1

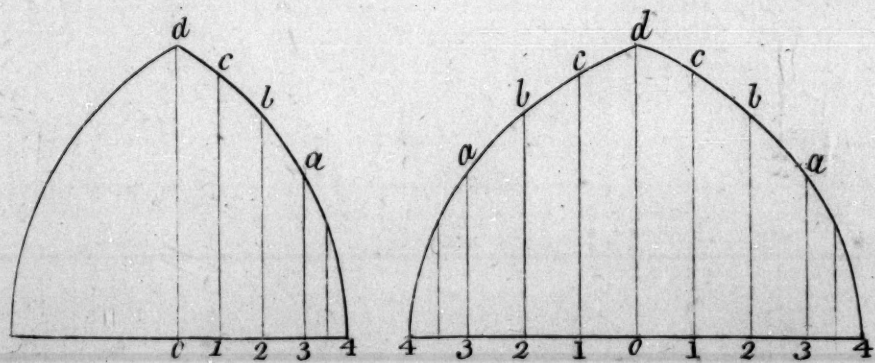


Fig F N. 2

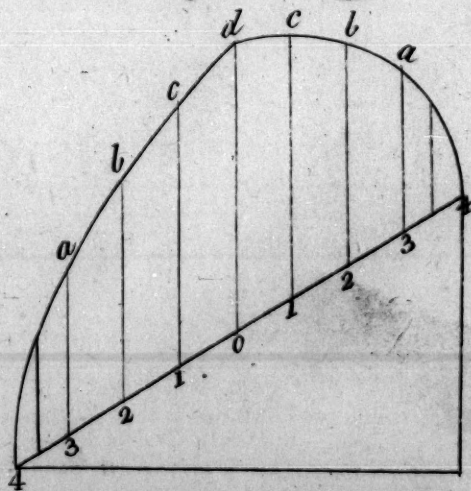






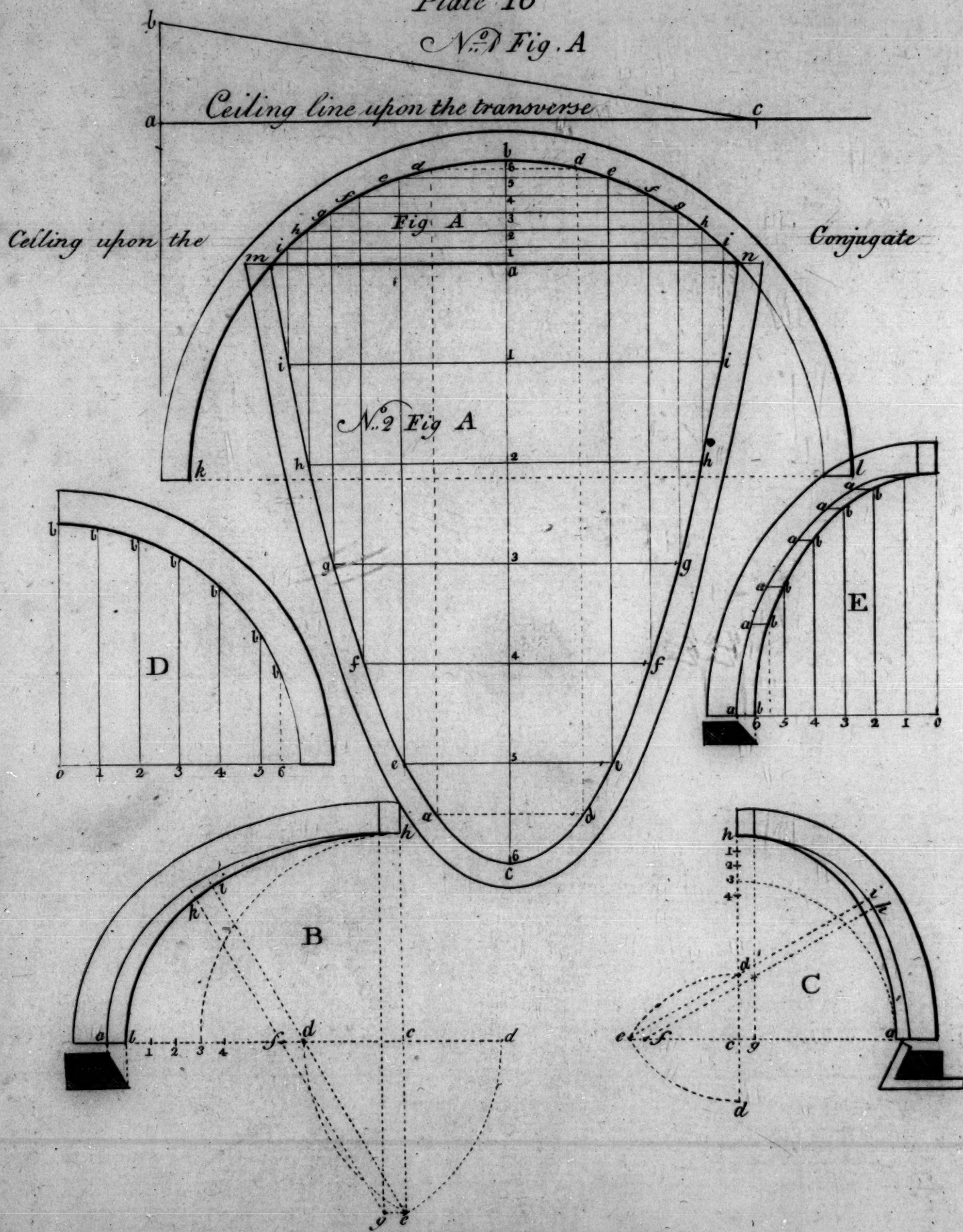






Plate 16

N<sup>o</sup> 1 Fig. A





## P L A T E XVI.

*As it happens sometimes in church work, that windows go higher than the ceiling line, therefore the ceiling wants to be hollowed out, so that the light may be thrown down into the body of the church; I shall, in this place, shew the method of making a curb for that purpose.*

*To find the form of the curb.*

Let  $k b l$  be the head of the window, figure *A*, and let it come as high as  $a b$ , above the ceiling\*; and let  $a b$  at No. 1 be the same height, and  $b c$  the direction of the light, and  $a c$  will be the length of the curb. Make  $a c$  at No. 2, equal to  $a c$  at No. 1, and divide it into six equal parts; also divide  $a b$ , in figure *A*, into six equal parts, and let the ordinates be drawn as is explained in the figure, a curve being traced round the points of intersection, will give the form of the curb.

\* The ceiling is here supposed to be level, which is seldom the case in a church; but the method will be nothing different if the ceiling line  $a e$  was to incline to the horizon in any angle whatever.

Figures *B* and *C* shew the method of drawing and backing any elliptic rib with a compass, which is exceedingly handy in drawing, and will be near enough for the representation of an elliptic rib on paper, as no other method will be so clean when done; but for practice, nothing is more handy than a trammel, or intersecting lines.

*To draw and back ribs by this method.*

In *B*, let  $c b$  be the height, and  $c b$  the width; divide the difference into three equal parts, and set four such parts on each side of  $c$ , to  $d$  and  $d$ , and make an intersection with the distance  $d d$  at  $e$ , and draw a line through  $e$  and  $d$  out to  $i$ , then  $d$  and  $e$  are the centres for the ribs. And suppose the rib is to be backed as much as  $a b$  upon the bottom, set  $a b$  from  $d$  to  $f$ , and from  $e$  to  $g$ , parallel to the base; and draw a line through  $g f$ , out to  $k$ ; then  $g$  and  $f$  are the centres for describing the backing.

The rib *E* is traced from *D*, and  $a b$  is set all round on the parallel lines, shews the backing is also used for drawing on paper.

The method of drawing the rib *C* is only the reverse of the other at *B*, and therefore wants no other description.

*Note.* The word *backing* signifies the beveling of any rib, so as to range in a straight or regular curve line with any other number of ribs already fixed; nothing is more difficult to understand in the practice, where groins or other arches meeting together do not form a straight line upon the plan, then the shifting of a mould cannot be applied to a curve surface as it is to a straight one; in this case we must have recourse to another method.



## P L A T E XVII.

## D E F I N I T I O N.

*Groins are the intersection of arches or vaults cutting across one another, meeting on their diagonal sections.*

## B R I C K G R O I N S. D E S C R I P T I O N.

*A, a, a, a, &c.* is the plan of the piers which the vault is to stand upon, *a b* is the end opening, which is a given semicircle; in this *b c* is the opening of the side arch, which is to come to the same height as the end arch *a b*: fix your centres over the body range, *fig. A*, as shewn in the section at *C*, then board them over. In *fig. A* is the manner of fixing the jack ribs upon the boards, which likewise shews at *C*.

*To find the mould for the jack ribs.*

Take the openings of your arches in *fig. A*, that is *a b* and *b c*, and lay them down in *fig. D*, at *a b* and *b c*, to make a right angle. Divide one half of the given semicircle *E* into five parts, and square them across 1 1 1, &c. to cut *d b* and *d c*, the diagonals, in 2 2 2, &c. and through the points 2 2 2, &c. draw lines parallel to 1 1 1, &c. the base of *E* both ways towards *F* and *G*; stick in nails at 1 2 3 4 5 in *E*, and bend a thin slip of wood round them, which mark with a pencil at every nail; this slip of wood being stretched out from *d*, 1 2 3 4 5, and squared over to *G*, will intersect the other lines in small squares: a curve being traced through the diagonals of each square, will give a mould for to set the jack ribs.

*How to fix the jack ribs.*

Bend your mould *G* from *d*, to the crown at *e*, in *fig. A*; that will give the edges of your boards; then fix a temporary piece of wood, level upon the crown, in the direction of *ff*, and let it come the thickness of your boards lower than the crown, then it will give the height of your jack ribs, which is a very sure method of placing them.

*To find a mould to cut the ends of the boards.*

The rib *F* is traced to the height of *E*, or got by a trammel, which will be fully exemplified in the following plates. Take the parts round *F*, and lay them out to 1 2 3 4 5; then *H* will be got in the same manner as *G*, which will be a mould to cut the ends of your boards that goes upon the jack ribs against the body range.

**FIG. 1.** *Is an easy method of getting the moulds when both arches are the same opening.*

Take half the opening of the arches, whatever they are, and draw a quarter circle, and divide it into six; bend a slip round it to take its parts, then stretch it out upon the base from 1 to 6, and square over your points 1, 2, 3, &c. Through the points in the arch draw the lines on both sides the other way, and being traced as before, gives both moulds, being the same in this.

*Note.* The curve *F* may be drawn in practice with a trammel, independent of the other, and the two moulds *F* and *G* may be drawn separate, without any connection of lines, as shall be shewn hereafter.



Plate 17

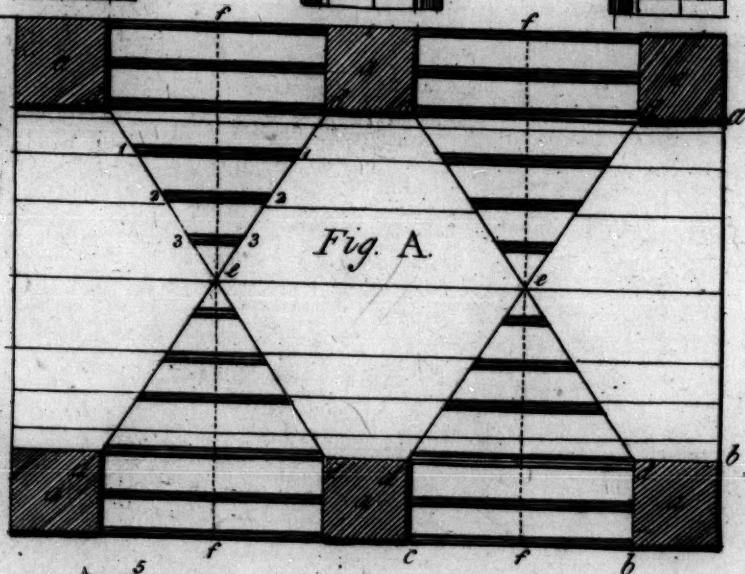
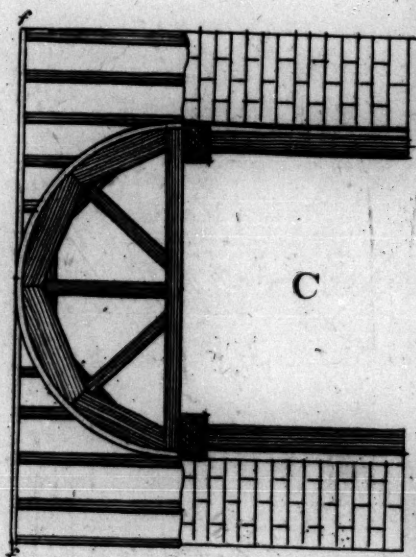
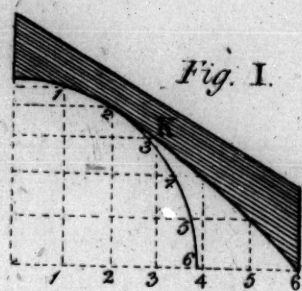
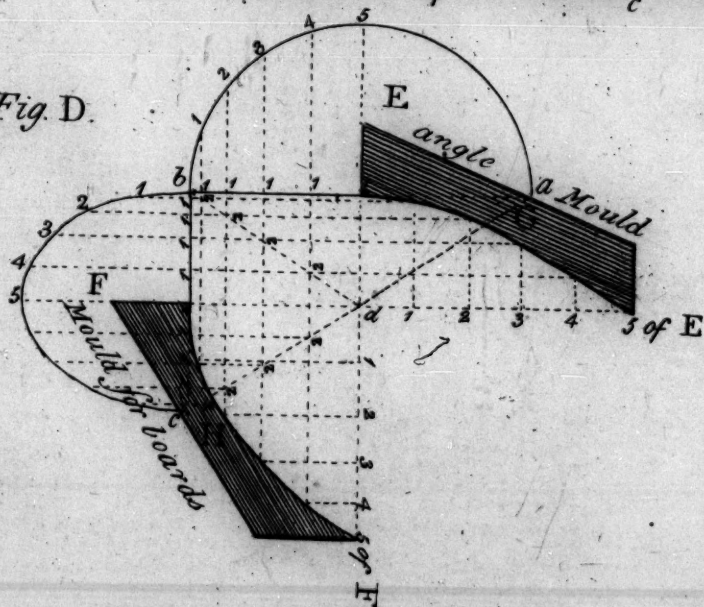


Fig. D.



Pub<sup>d</sup> as the Act direct June 6. 1793 by P. Nicholson.



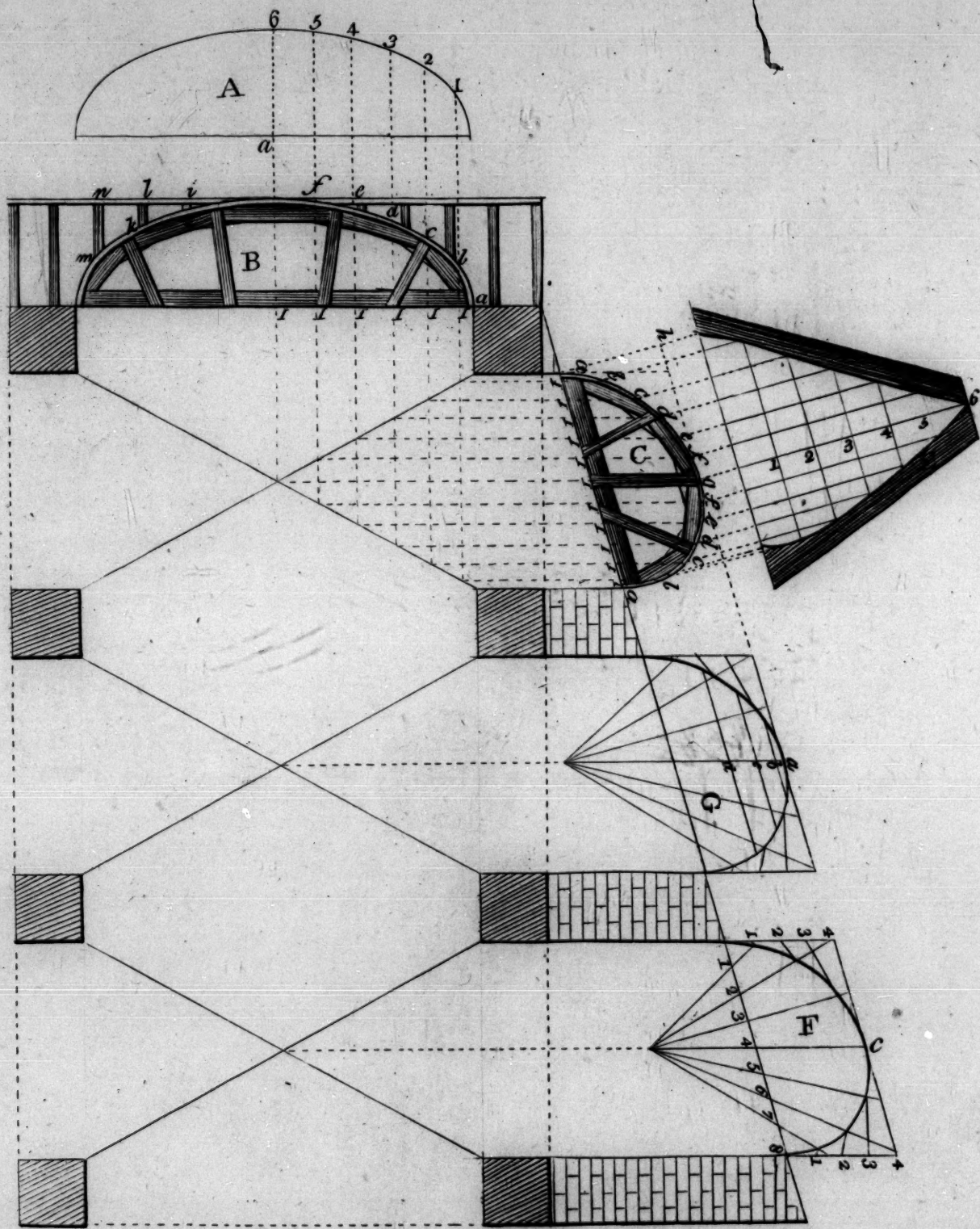








Plate 18



Pub<sup>d</sup> as the Act directs Nov 8 1792 by P Nicholson



PLATE XVIII.

DEFINITION.

*Groins are said to be ascending or descending when they are not built upon level ground.*

CENTERING FOR ASCENDING OR DESCENDING GROINS.

*The plan, and ascent or descent, of any groin being given, and one of the body ribs, as B, also the place of the angles upon the plan, to find the form of the side ribs, so that the intersection of both arches will be perpendicular over the plan.*

Divide half the circumference of the given rib B, into any number of equal parts, and draw them to intersect the angles; and from thence let them be returned up to the rib C, upon the side; then C being pricked from the given rib at B, as the letters direct, will give the form of the side centre. The same is shewn at F, by the method of intersecting lines.

*To find the two moulds D and E for placing the jack ribs, to bend over the angles in the body range, when boarded in, so that they may be perpendicular over the angles upon the plan.*

At C, draw lines from the points *a b c d e f g*, &c. where the ordinates of C intersect the top of the arch, and perpendicular to the rake, and draw the semi-ellipsis A, to the width of the body range; and to *a b*, the height of the side centres, perpendicular to the rake; and continue the ordinates of B, up to A, to intersect at 1 2 3 4 5 6. Bend a slip round these points, and mark them opposite to every point, and stretch it out along *k 1 2 3 4 5 6*, between D and E, and draw lines through these points, at right angles to *k 6*, to intersect with the perpendiculars. Begin at 6, and trace a curve both ways, will give the edges of the two moulds for placing the jack ribs.

*To cut the jack ribs to the rake of the groins.*

Set the number of the jack ribs upon the arch B, at their proper distances, and take their several heights, that is, *h i*, *k l*, and *m n*, and set them upon the arch G, from *a* to *b*, and from *a* to *c*, and from *a* to *d* draw lines through these points parallel to the rake, which will shew how the jack ribs are to be cut, so that they shall range properly with the other raking centres.

*Note.* All the body ribs must be backed according to the rake of the groin; to do this exactly the under edges of all the ribs must be beveled according to the rake; then make a mould as B, or one of the body ribs themselves will answer instead of a mould, which being applied to each side of any other rib, keeping the bottom fair with the under edge upon each side, and drawing the curves by the other, it will give the backing in this case.



## P L A T E XIX.

*Given the two side arches of any groin, and the ascent; to find the intersection of the angles upon the plan.*

Divide half of the body rib *B*, into equal parts, and draw parallel lines to *b c d e* and *f*; and on the point *a*, as a centre, draw the concentric dotted circles round to *g h i k l*; then draw parallel lines to the rake, to cut the centre *C*, at 1 2 3 4 5, and *a b c d e* on the other side; and from these points let lines be drawn perpendicular through the plan. And on the centre of the rib *C*, at *g*, square a line up to 5, the top of the arch *C*; and from 5 draw a line perpendicular through the plan. Also through the points 1 2 3 4 5, at *B*, draw perpendicular lines to the plan the other way; begin at *b*, and trace through the angles both ways, will give the place of the angles upon the plan.

The moulds for bending over the angles are found in the same manner as in the last plate, by taking the stretch out round *A*, and laying it between *D* and *E*.

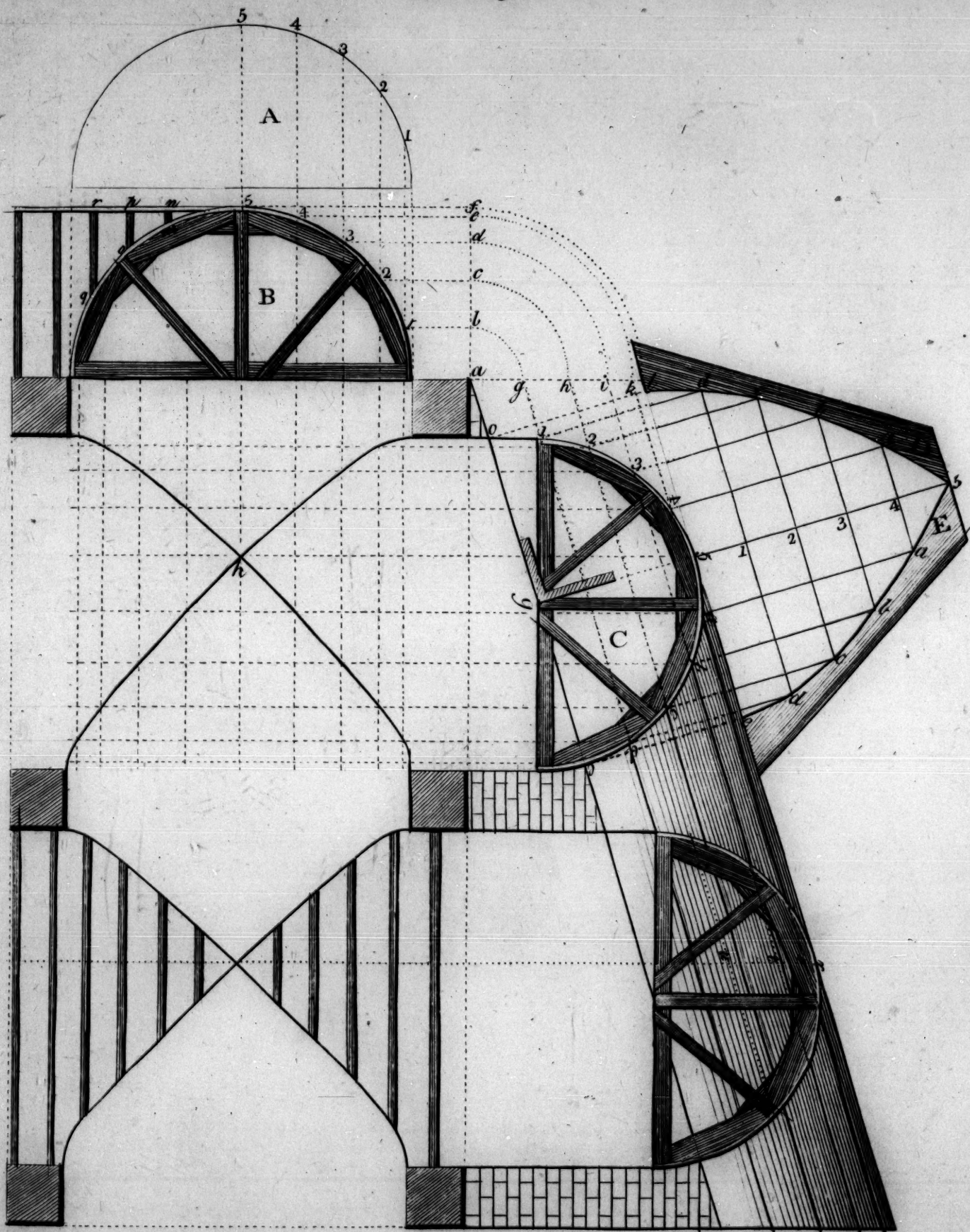
The Reader may see such groins executed under the Adelphi Buildings in the Strand, London, where the descent is very rapid in going down to the river.

The jack ribs of the groin are cut in the same manner as directed in the last plate, and in the practice there will be no occasion for tracing the angles, as the two moulds *D* and *E* are done independent of them: the Reader will farther observe, that the arch *B* must not be used instead of the arch *A*, which would produce a very great error in the moulds *D* and *E*, as it must be evident to every one, that the section upon the square of the cylinder, or body range, must be less in the height than the perpendicular or plumb section *B*, which in this case is oblique; if these things are properly understood, there will occur nothing in brick groins but what may be easily surmounted.

In all kinds of brick groins the centres or body ribs must be fixed first in the same manner as if there were no side-arches cutting across them; then the centres must be boarded over; then to find the place of the angles upon the boards, that is, the proper intersection of the side-arches upon the plan, the moulds *D* and *E* must be both bent round the boards at one time, by keeping the points *l* and *e* of the moulds *D* and *E* upon the tops of the piers at *o* and *e*; then keep the top points together, and bend them round, keeping them still together, then the point at 5, will fall perpendicular over *b* in the plan; round the inner edges of the moulds draw a curve upon the boards, which will be the proper intersection of the side-arch. The jack ribs are cut in the same manner as directed in the last.



Plate. 19



Pub<sup>d</sup> as the Act directs Nov. 8. 1792 by P. Nicholson.











Fig. 1.

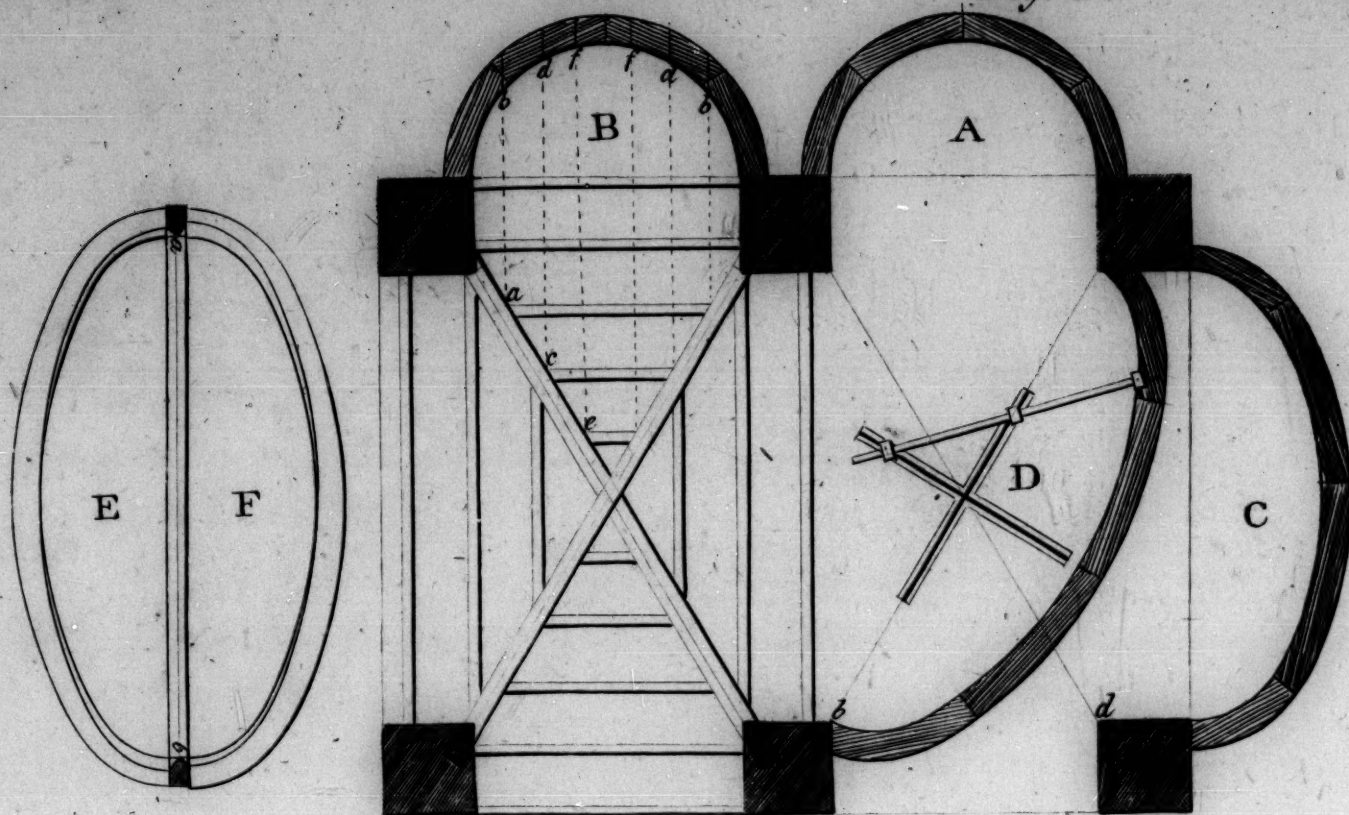
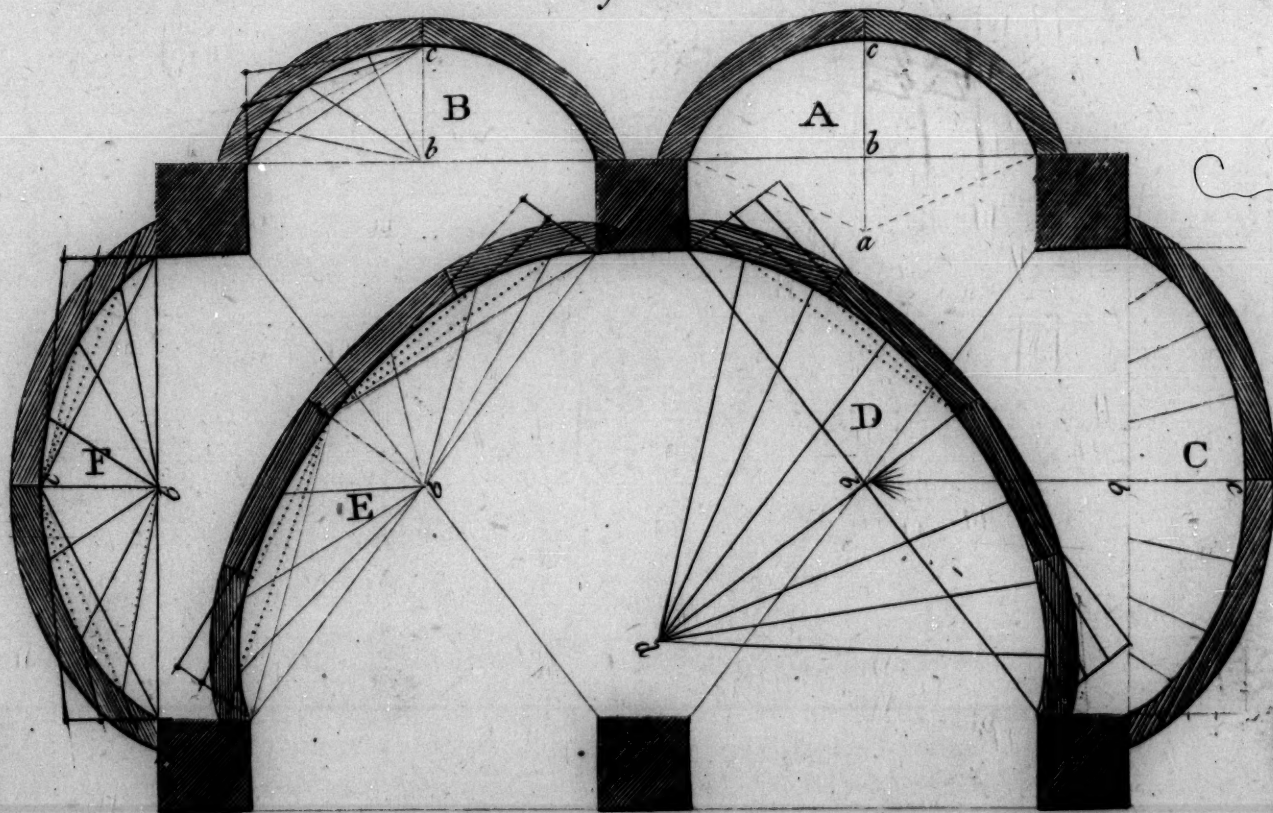


Fig. 2.





## P L A T E XX.

## P L A I S T E R G R O I N S.

*The angles or diagonals of any plaister groin, which are straight upon the plan, and one of the side arches being given, to find the other side arch and angle rib.*

FIG. 1. CASE 1. If the given rib is a semicircle semi-ellipsis they may be described as in fig. 2, plate 6, with a trammel, which is by far the readiest method; but if a proper trammel is not to be got, a temporary one may easily be made, which will answer equally as well, by fixing two pieces of wood in the form of a square, that is to make a right angle; each leg must be as long as the difference between the semi-transverse and semi-conjugate axis, and instead of the sliding nuts in the rod, two brad awls will answer the purpose, being put through any straight slip of wood, and by moving this round either the exterior or interior angles of the square, keeping the pins or brad awls close to each leg, it will describe one quarter of an ellipsis at one time.

*To find the length of the jack ribs.*

Lay down the plan of the ribs, as at *B*, and draw a rib upon each opening; then draw perpendicular lines from the plan of each opening, at the extremities *a c e*, to cut its corresponding rib at *b d f*; then the distance from *b* to *b* shews the length of the first jack rib, from *d* to *d* the length of the second, and from *f* to *f* the third.

*How to back or bevel the angle ribs, so that they shall range with each opening of the groin.*

First get the ribs out in two halves or thickneffes, as at *E* and *F*, then draw the plan of your angle rib which is placed between *E* and *F*, will shew the true bevel upon the bottom of the rib; then shift your hip mould parallel upon the base of *E* and *F*, will shew how much wood there is to be bevelled off; then nail the two halves together, and it will be completed.

## M E T H O D I.

FIG. 2. CASE 2. When the given rib is a segment of a circle, or any other curve whatever, the ribs will be described as in plate 15, fig. *E*, as are shewn at *B*, *E*, and *F*.

## M E T H O D II.

When the given arch is a segment of a circle as at *A*, take its height *b c*, and place it from *b* to *c* at *C* and *D*; then take the whole diameter of the arch *A*, that is, twice the radius *a c*, and place it from the crown of the other arches perpendicular to their bases from *c* to *b* at *C*, and from *c* to *d* at *D*; then the arch may be drawn as in plate 8, by intersecting lines: the backing of the ribs is done in the same manner as in the last groin.

Either of these two methods are much readier in practice than tracing the ribs through ordinates.



## P L A T E XXI.

*Given one of the body ribs, and the angles straight upon the plan, and the ascent of a groin not standing upon level ground, to find the form of the ascending arches, and the angle ribs.*

Let  $b a c$  at  $B$  be the angle of the ascent, from the point  $b$  make  $b c$  perpendicular to  $a b$ , and describe the rampant curve  $B$ , as in plate 15, at No. 3, in fig.  $E$ ; then draw the diagonal  $a b$  at  $E$ , and make  $b c$  perpendicular to it, and equal to  $b c$  at  $B$ ; then draw the hypotenuse  $a c$ , and describe the angle rib  $E$ , in the same manner as that of  $B$ .

*To find the length of the jack ribs, so that they shall fit to the rake of the groin.*

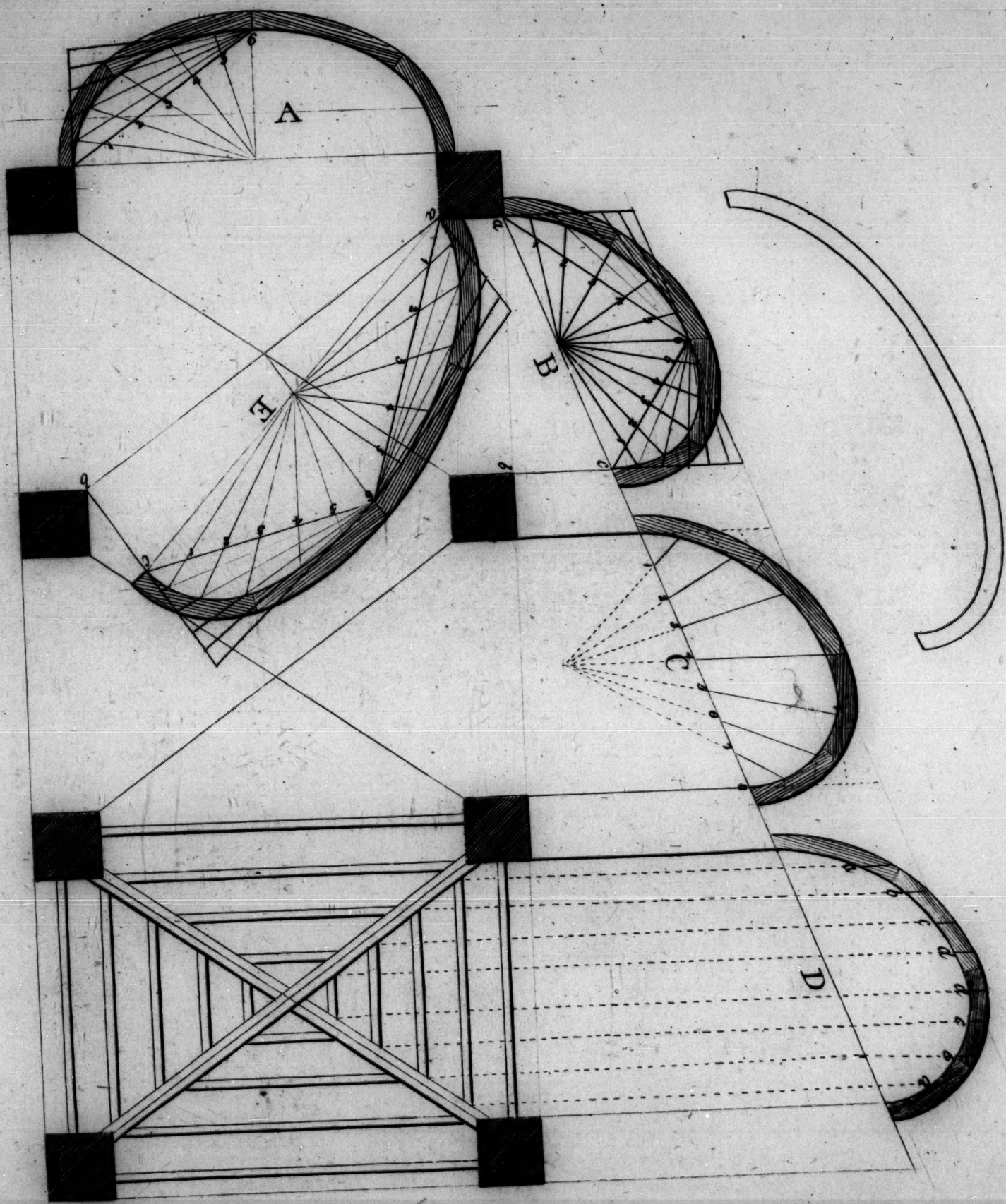
Draw lines up from the plan to the arch, as at  $D$ , in the same manner as explained in the last plate; then the arch from  $a$  to  $a$  is the first jack rib, from  $b$  to  $b$  the second, and from  $c$  to  $c$  the third, &c.

*How to back the angle ribs for such sort of groins, so that they shall range each way.*

Get the ribs out in two halves, as in the last plate, then the bottom of the ribs must be bevelled agreeable to the ascent of the groin, and the plan of it must be drawn upon the level, and from thence they may be drawn perpendicular from the plan to the rake of the rib; then take a mould to the form of the rib, or the rib itself, and slide this agreeable to the rake to the distance that is marked upon the bottom to be backed off, will shew how much the rib is to bevel all round.



Plate 21.





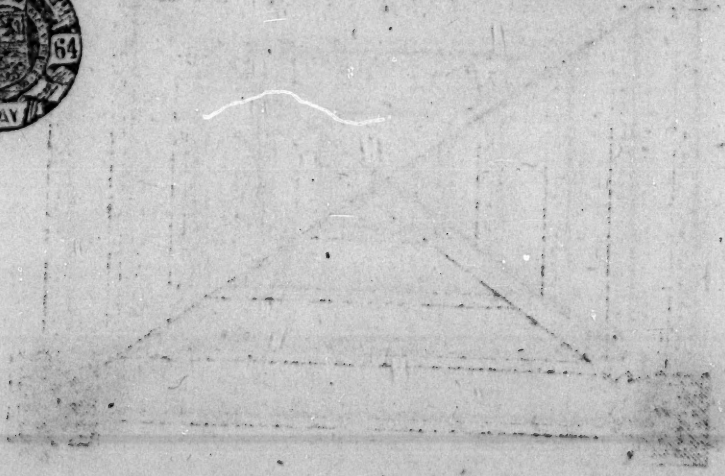
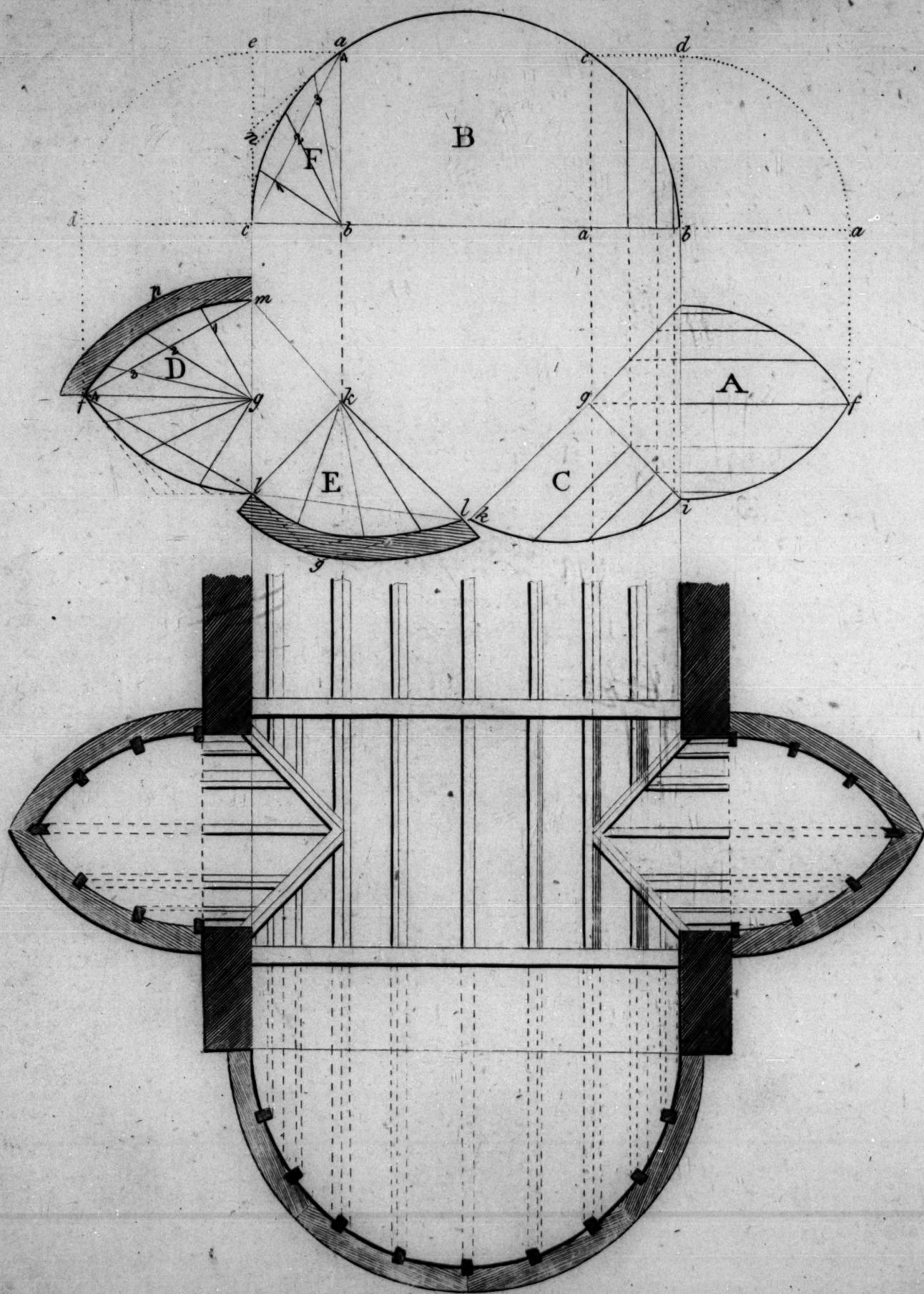








Plate 22.





## OF GROINS CUTTING UNDER PITCH.

## DEFINITION.

*When the side arches of a groin are lower than the body arch, then they are called under pitch groins.*

Given one of the body ribs  $B$ , and the height  $fg$ , of a door or window, &c. at  $D$ , and its width  $ml$ , to find the side and angle ribs  $D$  and  $E$ , so that the intersection of the side arch  $D$ , with the body rib  $B$ , shall be straight upon the plan.

Draw  $ce$  perpendicular to  $cb$ , the base of  $B$ , and equal to the height of the window at  $D$ , that is, equal to  $fg$ ; through  $e$  draw  $ea$  parallel to  $cb$ , cutting the arch  $B$  in  $a$ ; let fall the perpendicular  $ab$  to  $cb$ , and continue it so as to cut the line  $fg$  produced to  $k$ , and draw  $km$  and  $kl$ , which is the place of the angles upon the plan, or the base of the angle ribs: then the ribs  $D$  and  $E$  may be described from the given rib  $F$ , as directed in plate 15, fig.  $E$ , from a centre; or they may be described as at fig.  $F$  of the same plate, as you see on the other side at  $A$  and  $C$  by ordinates: but the first is by far the easiest method for practice, for if you stick a pin or brad awl in  $g$ , at  $D$ , and lay a chalk line to it, you may strike all the radial lines  $g1, g2, g3, g4$ , &c. in much less time than the parallel lines in  $A$  and  $C$  can be drawn, and with much greater accuracy; and the divisions upon  $cn$  of the arch  $F$ , may be marked upon a rod, and readily transferred to the arches  $D$  and  $E$ , on  $mp$ , and  $fg$ : then move your brad awl out of  $g$ , and stick it in the crown at  $f$ , and strike lines from the divisions of  $mp$  to cross the other lines, will give the points through which the arch must pass; but the Reader must recollect that four or five points will not be sufficient in the practice for tracing the curve with accuracy, and therefore a greater number must be found. At the other end of the groin is shewn the manner in which it may be fixed, sufficiently intelligible for a workman.



## PLATE XXIII.

## A WELCH GROIN.

## DEFINITION.

*A Welch groin is an under pitch groin, whose side and body arches are both given semicircles, or they may be similar segments of circles cutting through one another, whose intersections do not meet in a plane surface, that is, the place of the ribs will not be straight upon the plan, but will generate a curve line.*

*Given the body rib A, and the side rib B, of a Welch groin, to find a mould for the intersecting ribs.*

Divide half the arch *B* into any number of equal parts 1, 2, 3, 4, or they may be taken at discretion, and from these points let fall perpendiculars to *ab*, its base; produce them at pleasure; also from the same points 1, 2, 3, 4, draw lines parallel to *ab*, the base of *B*, to intersect the perpendicular line *ef*; transfer the divisions from *ef* to *eg*; then from the division of *eg* draw lines parallel to *pq*, to intersect the body rib *A* at the points *h u w y*; from these points draw perpendiculars to *pq*, its base, and continue them to intersect with the perpendiculars from *B*, at the points *k, l, m, n*, between *C* and *D*; then trace a curve through these points, which will be the place of the intersecting ribs upon the plan; then draw two other curve lines on each side of *k, l, m, n*, &c. to make the thickness of the rib upon the plan; on the inside of the curve draw two chords for each half to their extremities, draw two other lines parallel to them to touch the outside curve, then the distance between those two straight lines will shew what thickness of stuff it will take to make the intersecting rib; through the points *k l m n*, &c. draw perpendicular lines to the chords, make the heights *c d, 3 3, 2 2, 1 1*, &c. at *D*, equal to their corresponding heights at *B*; then *D* is the mould for the intersecting rib; *C* is the same as *D*.

*To bevel the ribs, so that they will stand perpendicular over the plan.*

At the points *x v t i*, draw the parallel dotted lines to the ordinates of *C* and *D*, and make their corresponding heights equal to these of the arch *B* or *A*; draw the dotted curve line *h u w y* at *C*, and it will shew how much is to be bevelled off on that side of the rib; in like manner the other side *D* is bevelled, as is shewn by the dotted curve line.

*To find a mould to bend under the intersecting ribs, so that it shall give the place of the angle truly upon the plan.*

Take the stretch round the under side of the rib *D* at the dots, by bending a thin slip of wood round it, mark it at each dot, and stretch it out along the straight line *bc* at *E*, draw the ordinates across, and prick them from the plan that lies between *D* and *C*, then *E* agreeable to the letters will be the mould required.

*Note.* The straight edge of the mould must be kept exactly to the face of the rib; when it is bent round, then draw a curve round the under side of the rib, by the other edge of the mould, will give the true place of the angle.



Plate 23.

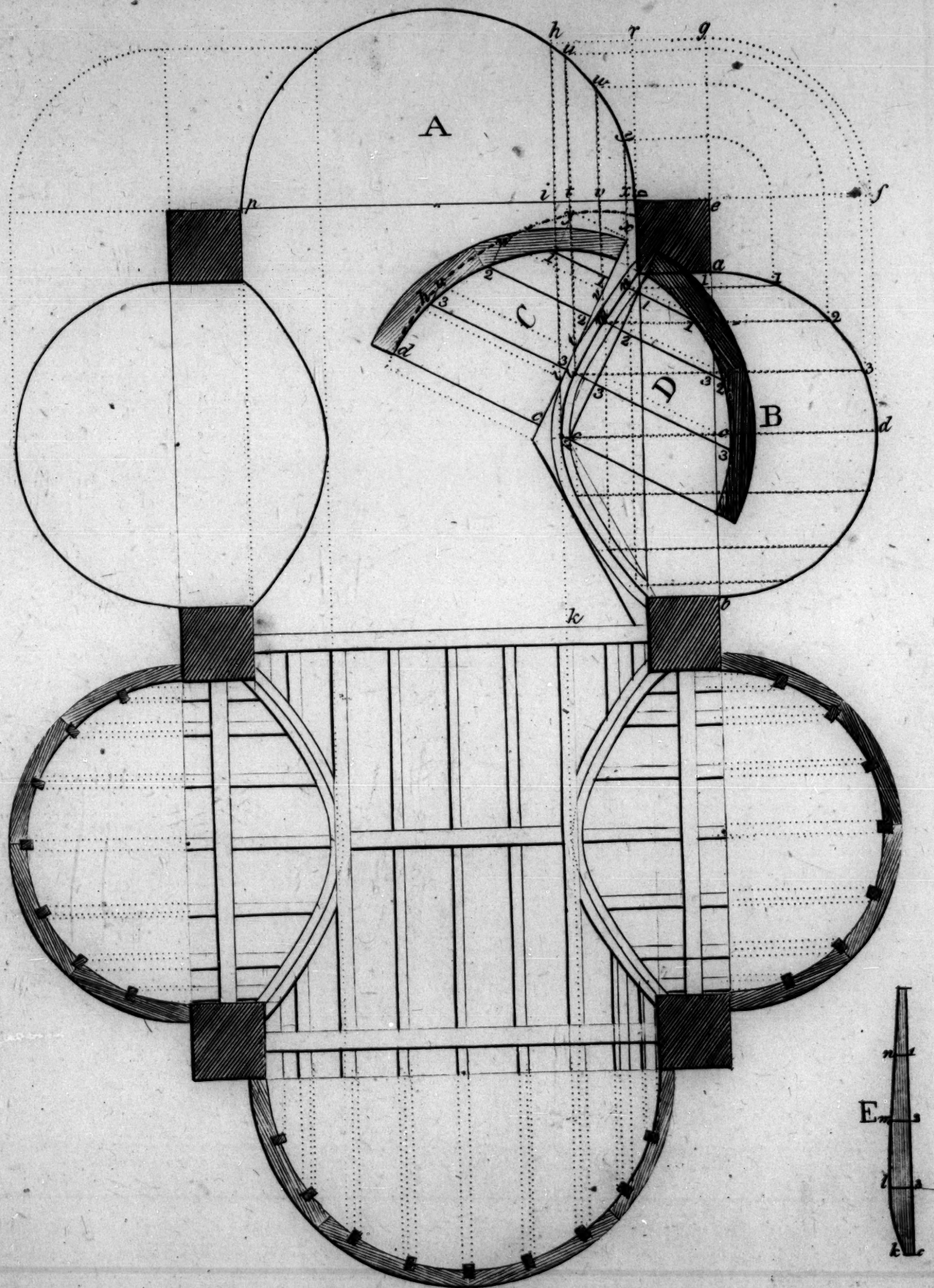












Plate 24.

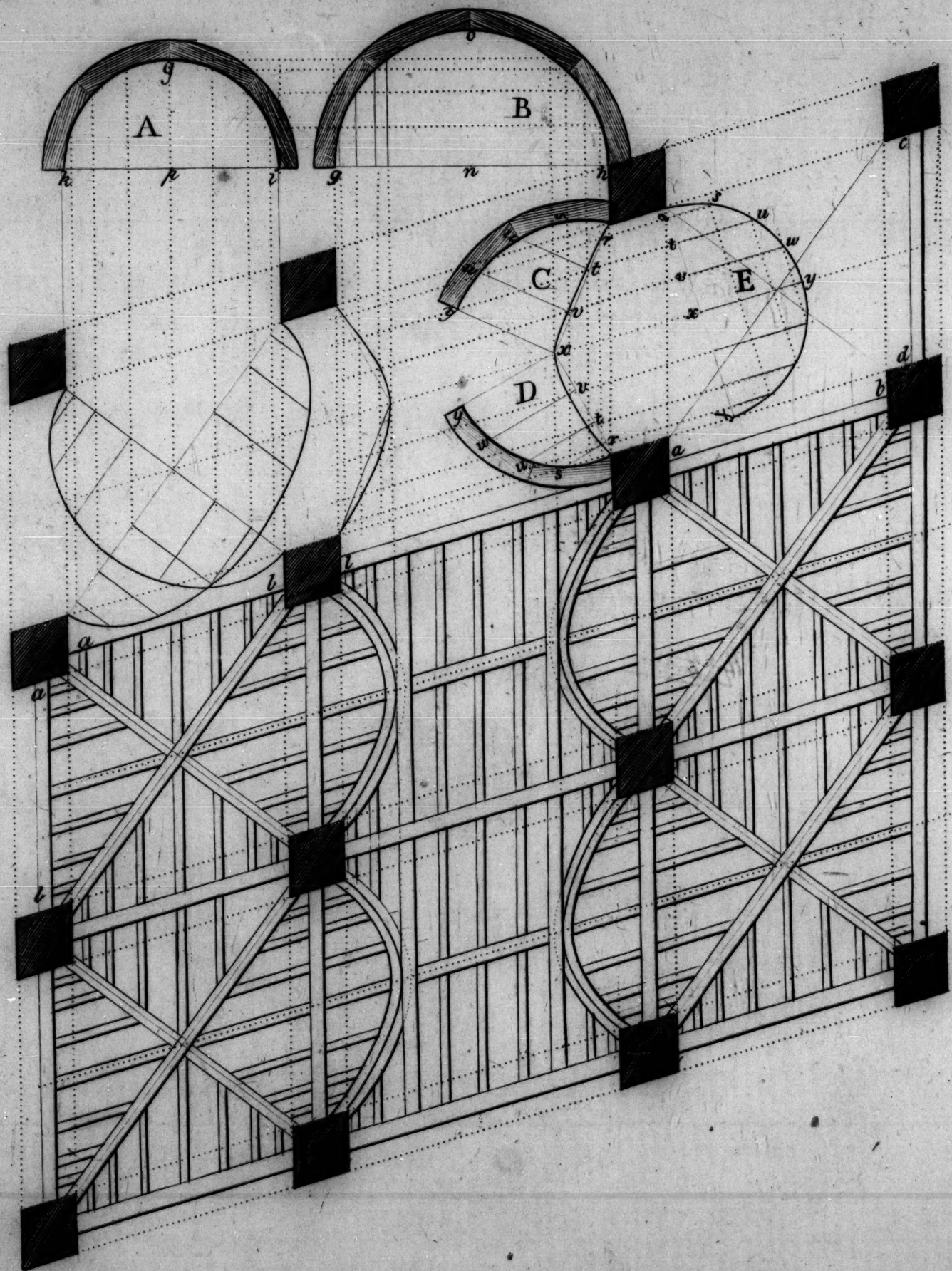








Plate 25.

Fig. A.

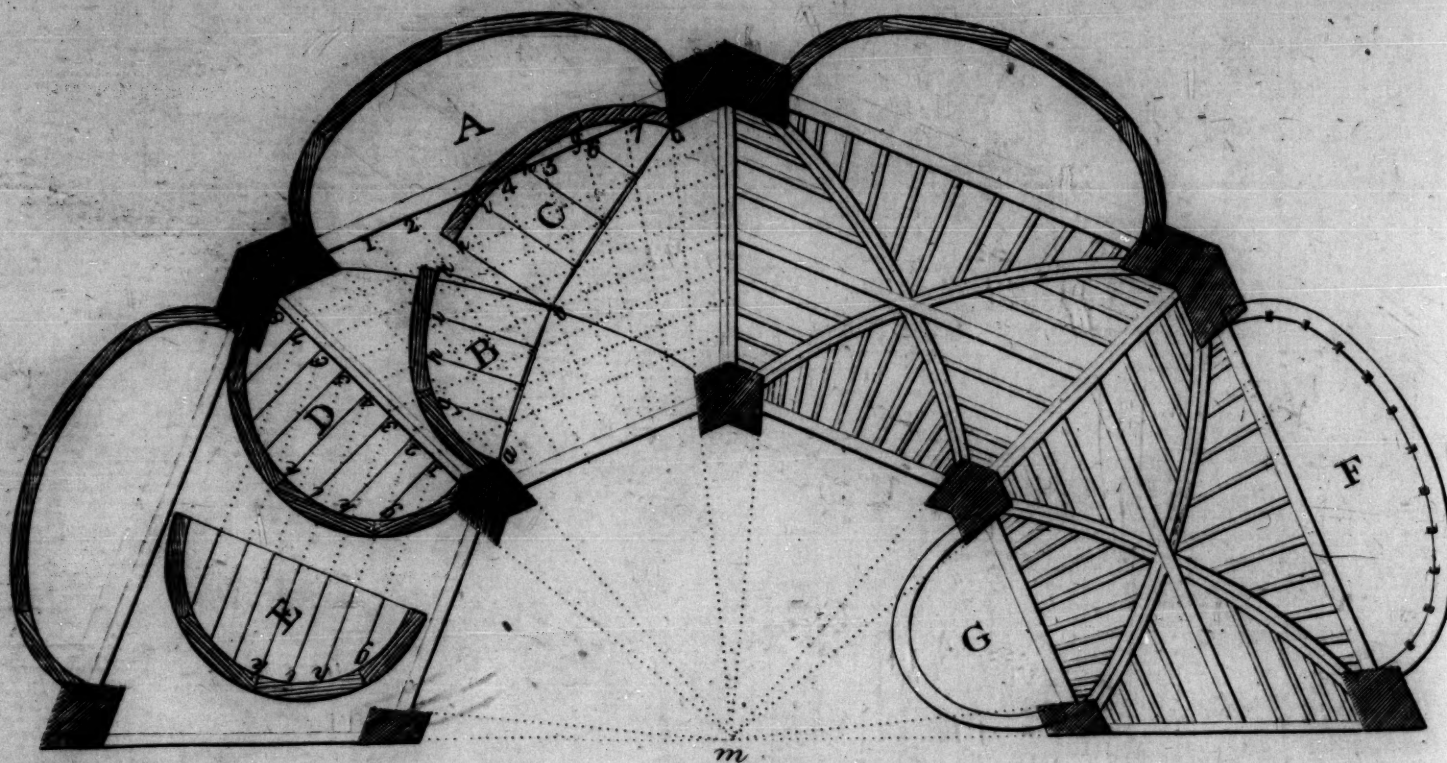
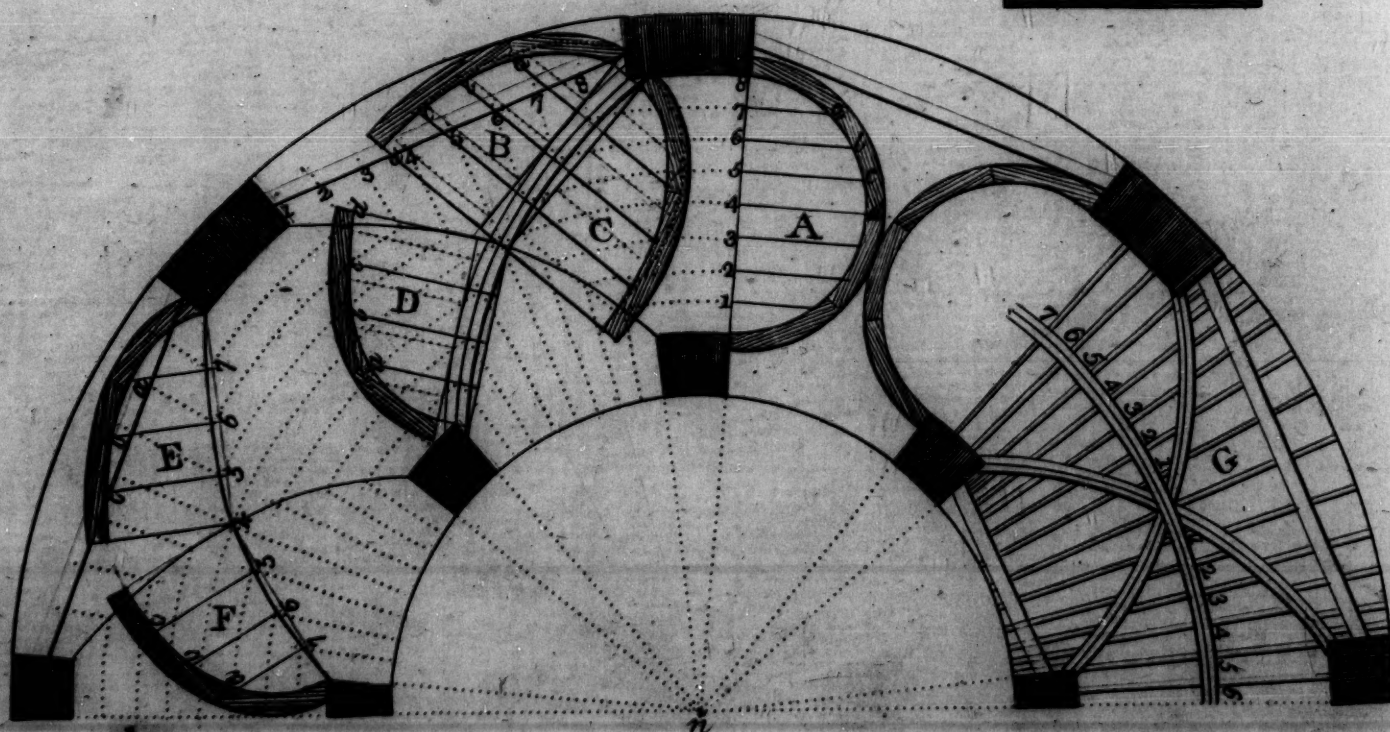


Fig. 2.





## P L A T E XXIV.

There will be no occasion for explaining the lines of this groin, as they are of the same nature as those in the last plate; but it will be proper to take notice, as this is a bevel groin, the ribs must lie in the same direction as the plan of the groin, which will make them longer than their corresponding given arches at the top, but of the same height; they are consequently ellipses, being the sections of cylinders, therefore to make a rib over  $lm$  across the two piers take the extent of the base  $lm$ , and the height of the given arch  $ns$ , and describe an ellipsis; and to describe the side arches between any two piers, as from  $a$  to  $b$ , take the extent  $ab$ , and the height of the given arch  $pg$ , at  $A$ , and describe an ellipsis, it will give the proper form of the rib to stand over  $ab$ ; the intersecting ribs will require two moulds  $C$  and  $D$ , owing to the groins being bevel upon the plan.

*Note.* The letters are marked the same upon  $D$  and  $C$  as they are upon  $E$ , to shew they are traced from it.

## P L A T E XXV.

*To describe the intersecting or angle ribs of a groin standing upon an octagon plan, the side and body ribs being given both to the same height.*

FIG. 1.  $E$  is a given body rib which may be either a semicircle or a semi-ellipsis, and  $A$  is a side rib given of the same height;  $D$  is a rib across the angles, trace from  $E$ , the basis of both being divided into a like number of equal parts, divide the base of the given rib  $A$ , into the same number of parts; from these points draw lines across the groin to its centre at  $m$ , and from the divisions of the base of the other rib  $D$ , draw lines parallel to the side of the groin, then trace the angle lines through these squares, will be the place of the intersecting ribs, draw the chords  $ab$ , and  $bc$ , then prick the moulds  $B$  and  $C$  from  $E$  or  $D$ , but take care not to prick them from the crooked line at the base, but from the straight chords  $ab$ , and  $bc$ .

*To describe and back the angle ribs of a groin circular upon the plan, the side and body arches being given, as in the last groin.*

The ribs are described in the same manner as in the last example for the octagon groin, or in the same manner as the Welch groin, plate 23, and the backing or bevelling is found in the same manner as is described in that plate.

*Note.*  $E$  and  $F$  are the same moulds as are shewn at  $B$  and  $D$ .



## P L A T E XXVI.

*The side rib A, and the angles being given straight upon the plan, to find the angle rib C, and the body rib C.*

FIG. 1. The rib *A* is supposed to be placed over the straight line *ab*, and its base divided into any number of equal parts, as 8; from the divisions draw lines to the centre of the groin, to intersect the angles at the points *abcdefg*; place the foot of your compass in the centre of the groin, and from the points *abc d*, &c. draw lines to the base of *C*, and make the ordinates of *C* equal to those of *A*, then *C* is the body rib; draw lines at right angles from the points *abc d*, &c. and prick the moulds *G* and *B* from *A*, will be the angle ribs required; this wants no mould to bend under the angle rib, as in the others that are crooked upon the plan.

*How to describe the ribs of a groin over stairs upon a circular plan, the body rib being given.*

FIG. 2. Take the tread of as many steps as you please, suppose nine, from *E*, and the heights corresponding to them, which lay down at *F*; draw the plan of the angles as in the other groins, and take the stretch round the middle of the steps at *E*, and lay it from *a* to *b* at *F*; make *de* perpendicular to *bc* at *B*, equal to *de* at *F*, draw the hypotenuse *ec*, draw perpendiculars from *dc* up to *B*, and prick *B* from *A*, as the figures direct, then *B* is the mould to stand over *ab*; draw the chords *a 4*, and *4 m* at the angles, make *a 9*, *4 b*, perpendicular to them, each equal to half the height *de*, at *B* or *F*, draw the hypotenuse *g 4*, and *b m*, draw the perpendicular ordinates from the chords through the intersection of the other lines that meet at the angles, then trace the moulds *D* and *C*, from the given rib *A*, will form the moulds for the angle or intersecting ribs.

*Note.* The reason that the angle ribs *D* and *C* are laid contrary ways, is only to avoid confusion.



Plate 26.

Fig. 1.

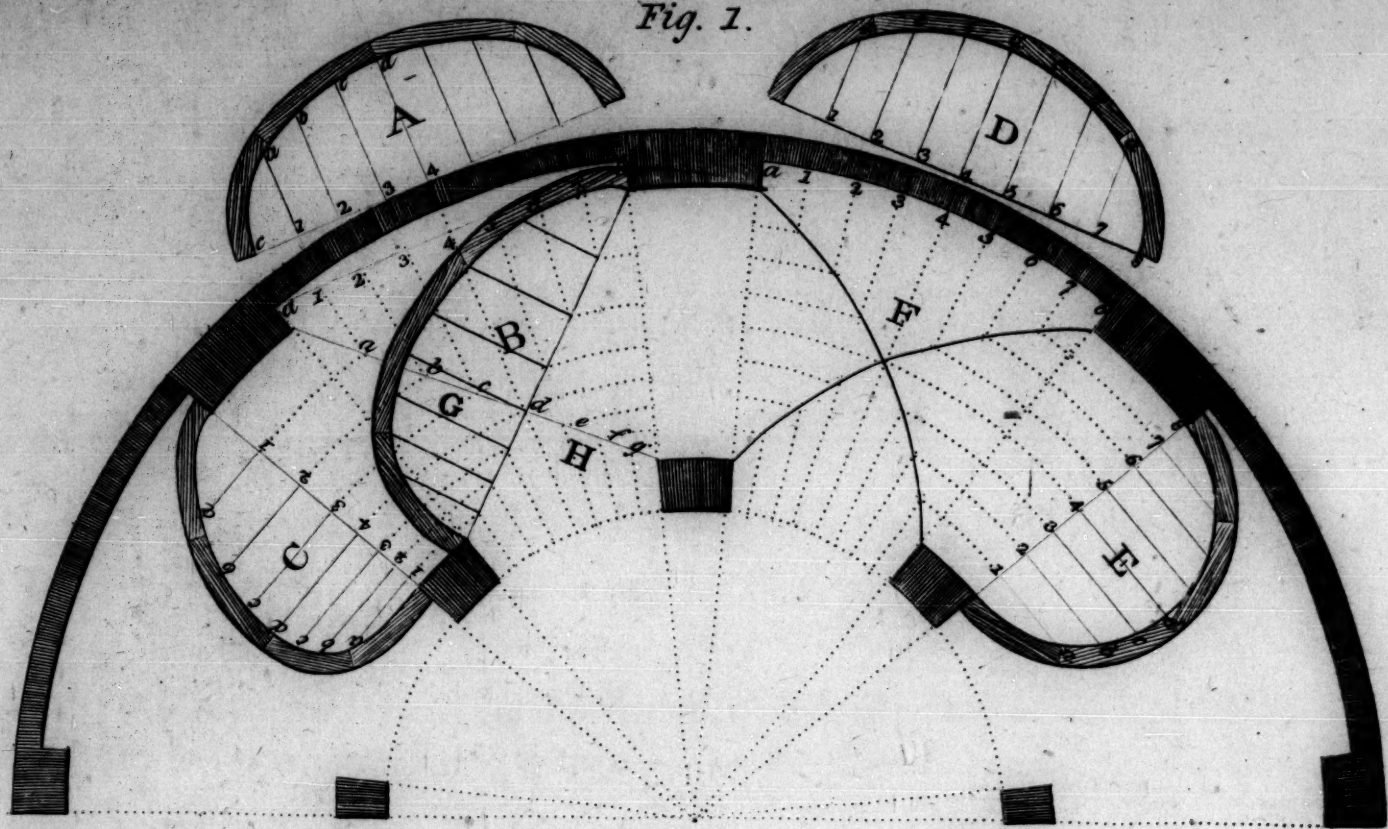


Fig. 2

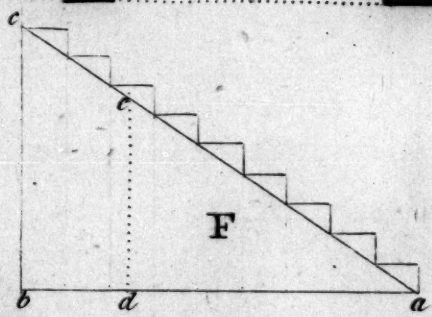
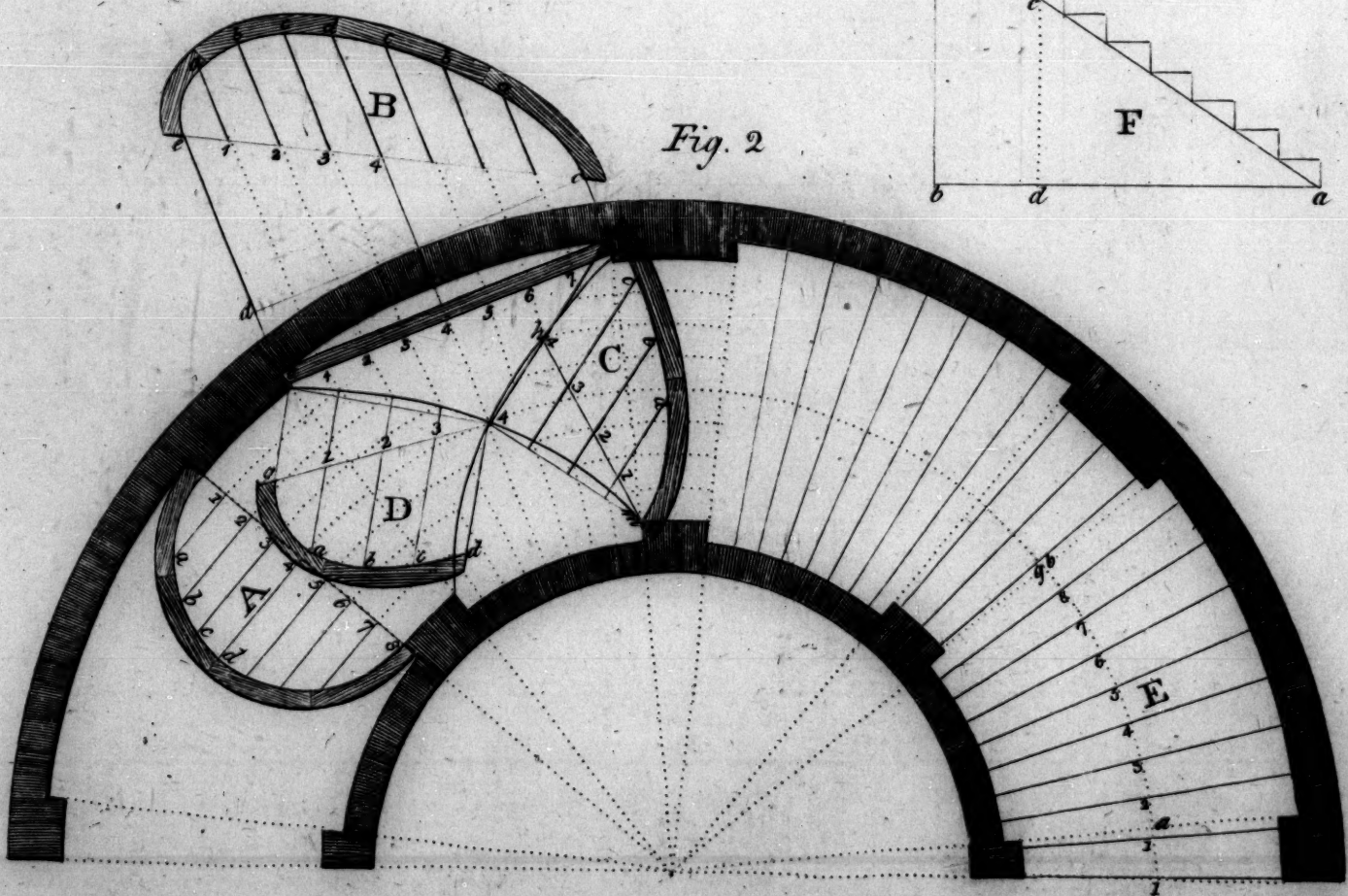




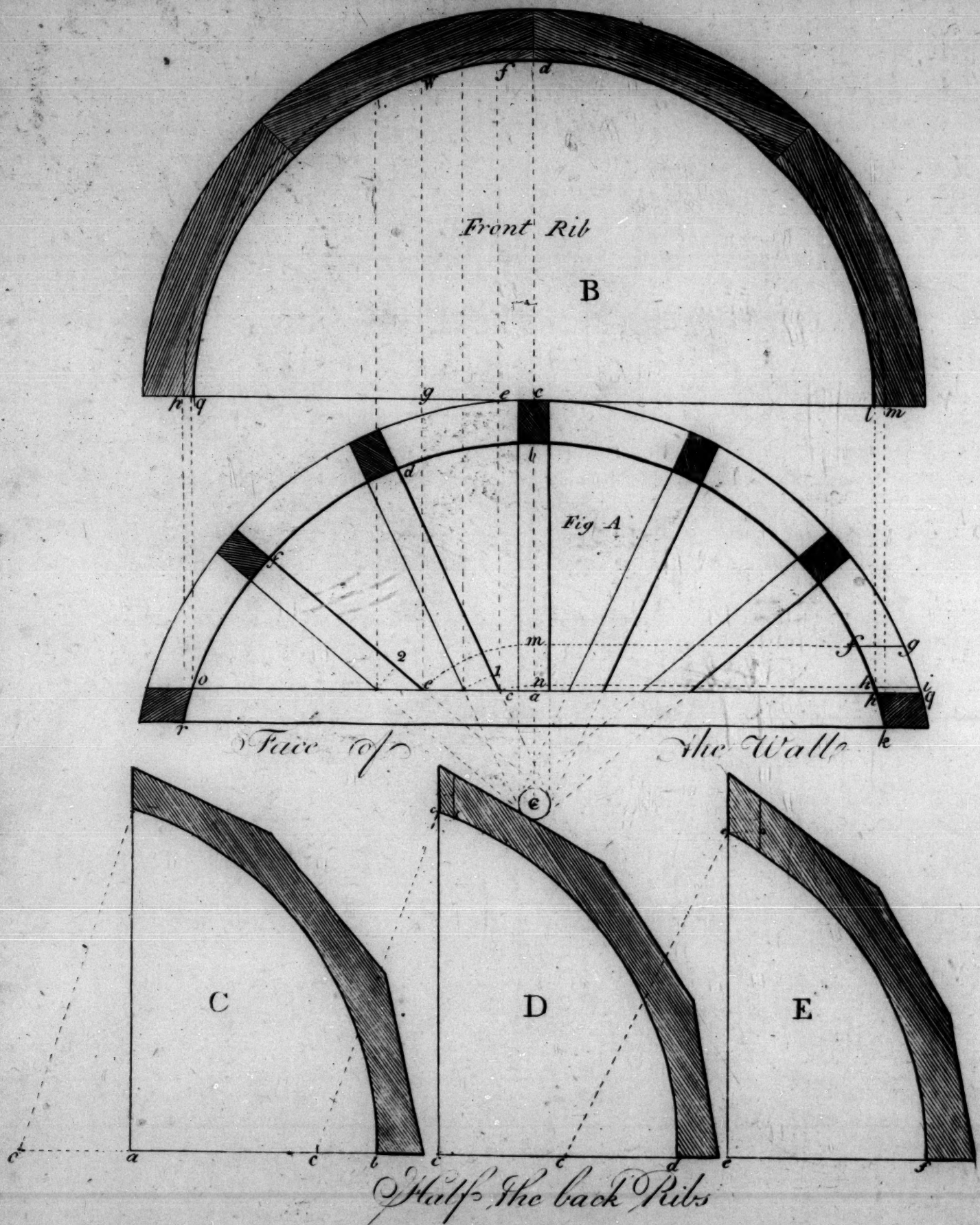








Plate 27.



Pub<sup>d</sup> as the Act directs Sep<sup>r</sup> 4. 1793. by P. Nicholson.



## PLATE XXVII.

*As the surface of a globe is every where of the same curvature, consequently the surface of any segment of a globe, or part, must still retain the same curve as before it was cut; and for this reason, it appears that the curves of the back ribs of a niche must be the same sweep as the ground plan itself; and the front rib is a semicircle. See Axiom the 3d, page 14, and figure 1, plate 10. If a semi-globe is cut by a plane at right angles to the plane of its base, then the section is a semicircle. The practice of this is easy.*

*To get out the ribs for the head.*

From the centre *c* draw the ground plan of the ribs as at figure *A*, and set out as many ribs upon the plan as you intend to have in the head of the niche; and draw them all out towards the centre at *c*. Place the foot of your compass in the centre *c*, and from the ends of each rib, at *e* and *c*, draw the small concentric dotted circles round to the centre rib at *m* and *n*; then draw *mg* and *ni*, parallel to *ek*, the face of the wall; then from *q* round to *e* upon the plan, is the length and sweep of the centre rib, to stand over *ab*; and from *i* round to *e*, the length and sweep of the rib that stands from *c* to *d* upon the plan; and from *g* round to *e* is the sweep of the shortest rib, that stands from *e* to *f* upon the plan.

*How to bevel the ends of the back ribs against the front rib.*

The back ribs are laid down distinct by themselves at *CD* and *E*, from the plan. Take *c* *r*, in figure *A*, and set it from *c* to *r* in *D*, will give the bevel of the top of the rib *D*. And from figure *A*, take from *e* to *2* upon the plan, and set it from *e* to *2* in the rib *E*, will give the bevel of the top.

*To find the places of the back ribs where they are fixed upon the front.*

From the points *a* *c* and *e*, at the ends of the ribs, in the plan, figure *A*, draw the dotted lines up to the front rib, to *d* *f* and *w*, which will shew where they are to be fixed upon the front rib. The double circle upon the front rib shews the backing.



## P L A T E XXVIII.

*To find the curve of the ribs of a globular niche, the plan and elevation being given segments of circles.*

In *fig. A* is the elevation of the niche, being the segment of a circle whose centre is *t*, at *B* is the plan of the same width, and may be made to any depth, according to the place it is intended for, and its centre is *c*; on the plan *B*, lay out as many ribs as you think it will take, draw them all tending to the centre at *c*, they will cut the plan of the front rib in *g f e d*; through the centre *c*, draw the line *m n*, parallel to *a b*, the plan of the front rib; put the foot of your compass in the centre at *c*, draw the circular lines from *a, g, f, e, d*, to the line *m n*, and make *c s* equal to *u t*, that is, make the distance from the middle of the chord line *m n* to *s*, the centre of the arch at *C*, equal to the distance from the middle of the chord of the top at *fig. A*, to its centre at *t*; then place the foot of your compass in *s*, as a centre, and from the extremities *m* or *n*, describe the arch at *C*, with the same centre draw another line parallel to it, to any breadth as you intend your ribs shall be, then *C* is the true sweep of all the back ribs in the niche.

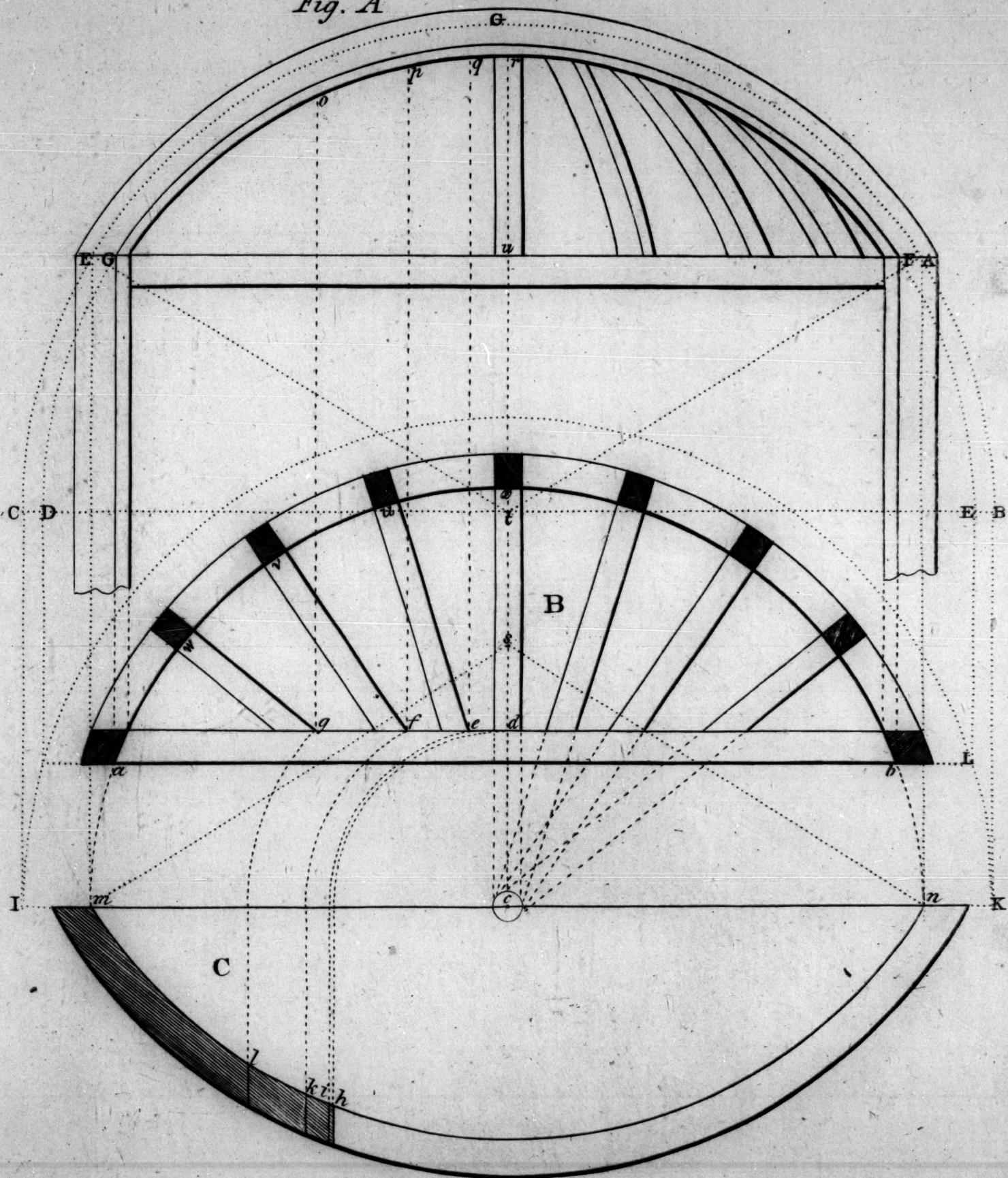
*Note.* The points *l k i b*, shew what length of each rib will be sufficient from the point *m*; from *b* to *m* is the rib that will stand over *d x*, from *i* to *m* is the rib that will stand over *e u*, from *k* to *m* over *f v*, and from *l* to *m* over *g w*; the other half is the same.

The truth of this is easy to be conceived by those who have previously studied the Sections of a Globe, in plate 10 of this book.

Through the centre *t*, draw *D E*, parallel to *a b*, complete the sweep of the top, *G F*, to the line *D E*, then *D E* is the diameter; through *n* draw *n A* parallel to *u d*, in the centre *t*; with the distance *t A* describe another semicircle, whose diameter is *c b*; then will the semicircle *c F G A B*, be equal to a vertical section of the globe, standing on *I K*, passing through its centre at *c*, which is the same sweep as the rib at *C*, because *u A* is equal to *c n*, and *c s*; bisecting *m n* at right angles, is equal to *t u*, bisecting *E A* at right angles; therefore the hypotenuse *t A*, that is, the radius of the circle *B A G E C*, is equal to *s n*, the radius of the circle or rib at *C*.



*Fig. A*







2

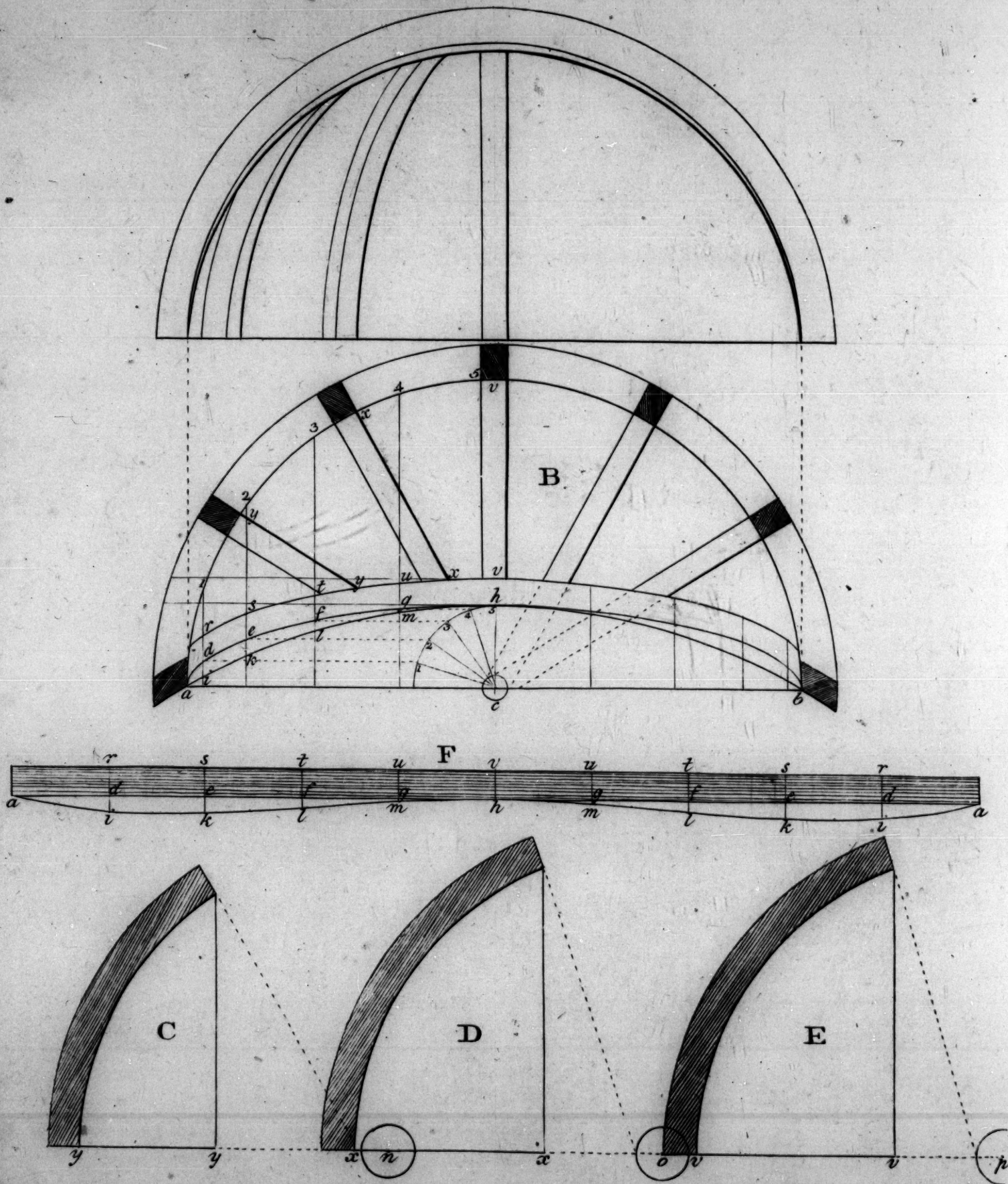






Plate 29.

Fig. A





## PLATE XXIX.

*The plan of a niche being given, standing in a circular wall, to find the front rib.*

*B* is the plan given, which is a semicircle whose diameter is *a b*, and *a, i, k, l, m, b*, the front of the circular wall; suppose the semicircle *B* to be turned round its diameter *a b*, so that the point *v* may stand perpendicular over *b* in the front of the wall, the seat of the semicircle standing in this position upon the plan will be an ellipsis; therefore divide half the arch *B* upon the plan into any number of equal parts, as 5; draw the perpendiculars 1 *d*, 2 *e*, 3 *f*, 4 *g*, 5 *h*, upon the centre *c* with the radius *c b*, describe the quadrant of a smaller circle, which divide into the same number of equal parts as are round *B*; through the points 1, 2, 3, 4, 5, draw parallel lines to *a b*, to intersect the others at the points *d, e, f, g, h*; through these points draw a curve, it will be an ellipsis; then take the stretch out of the rib *B*, round 1, 2, 3, 4, 5, and lay the divisions double at *F*, stretched out; take the same distances *d i, e k, f l, g m*, from the plan, and at *F* make *d i, e k, f l*, equal to them, which will give a mould to bend under the front rib, so that the edge of the front rib will be perpendicular *a, i, k, l, m*.

*Note.* The sweep of the front rib is a semicircle, the same as the ground plan, and the back ribs at *C D* and *E* are likewise of the same sweep.

The reason of this is easy, the niche being part of a globe, the curvature must be every where of the same sweep, and consequently the ribs fit upon that curvature.

*Note.* The curve of the mould *F* will not be exactly true, as the distances *d i, e k, f l*, &c. are rather too short for the same corresponding distances upon the soffit at *F*, but in practice it will be sufficiently near for plaister work; but those who would wish to see a method more exact, may examine plate 15, fig. *A*, where *C* is the exact soffit that will bend over its plan at *B*.

In applying the mould *F* when bent round the under edge of the front rib, the straight side of the mould *F* must be kept close to the back edge of the front rib, and the rib being drawn by the other edge of the mould, will give its place over the plan.



## P L A T E XXX.

*The plan and elevation of an elliptic niche being given, to find the sweep of the ribs.*

FIG. A. Describe every rib with a trammel, by taking the extent of each base from the plan whereon the ribs stand to its centre, and the height of each rib to the height of the top of the niche, it will give the true sweep of each rib.

*To back the ribs of the niche.*

There will be no occasion for making any moulds for these ribs, but make the ribs themselves; then there will be two ribs of each kind; take the small distances 1  $e$ , 2  $d$ , from the plan at  $B$ , and put it to the bottom of the ribs  $D$  and  $E$ , from  $d$  to 2, and  $e$  to 1; then the backing may be drawn off by the other corresponding rib; or the backing may be drawn off with the trammel, as for example at the rib  $E$ , by moving the centre of the trammel towards  $e$ , upon the line  $e c$ , from the centre  $c$ , equal to the distance 1  $e$ , the trammel rod remaining the same as when the inside of the curve was struck.

*Given one of the common ribs of a cove bracket, to find the angle bracket for a square or rectangular room. FIG. H.*

Let  $H$  be the common bracket,  $b c$  its base; draw  $b a$  perpendicular to  $b c$ , and equal to it, draw the hypotenuse  $a c$ , which will be the place of the mitre; take any number of ordinates in  $H$ , perpendicular to  $b c$ , its base, and continue them to meet the mitre line  $a c$ , that is, the base of the bracket at  $I$ ; draw the ordinates of  $I$  at right angles to its base; then the bracket at  $I$ , being pricked from  $H$ , as may be seen by the figures, will be the form of the angle rib required.

*Note.* The angle rib must be backed either externally or internally, according to the angle of the room.

*Having given a common bracket  $K$ , see fig. G, for plaster, to find the mitre bracket  $L$ .*

Proceed as in the last example, and you will have the bracket required.



Plate 30.

Fig. A

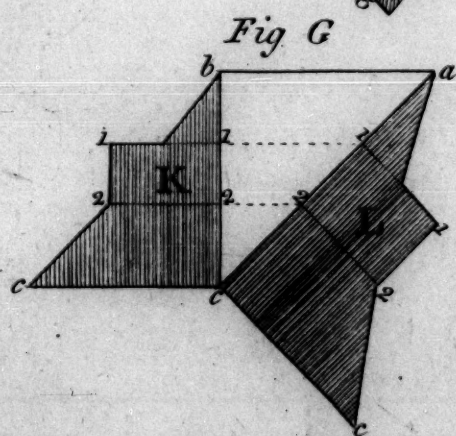
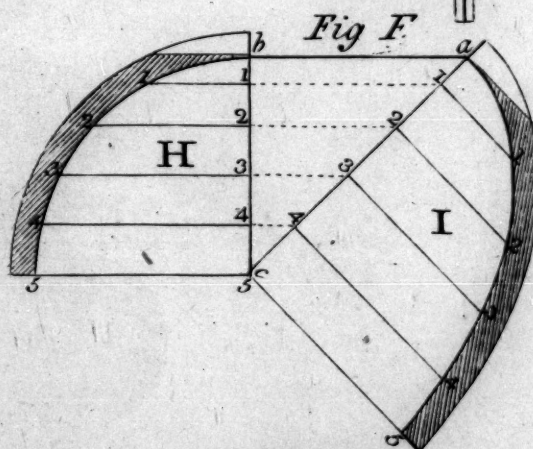
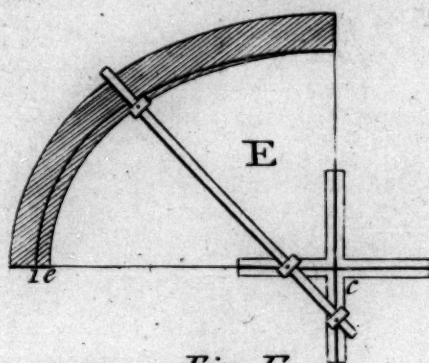
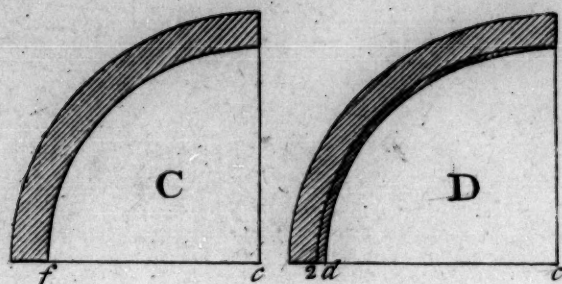
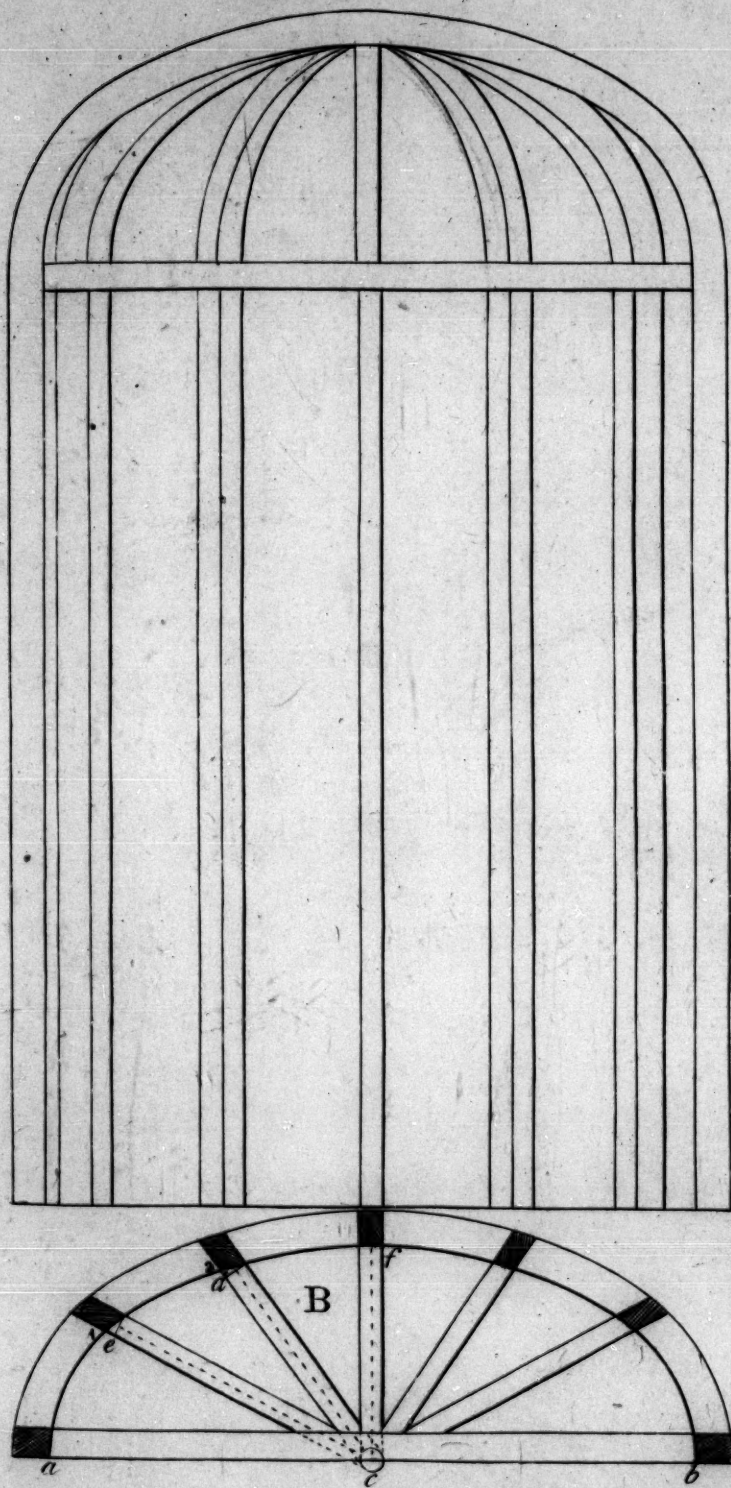












Plate. 31.

Fig. A.

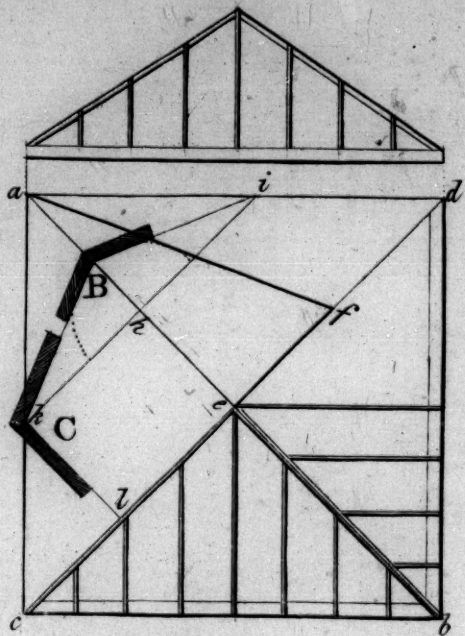


Fig. B.

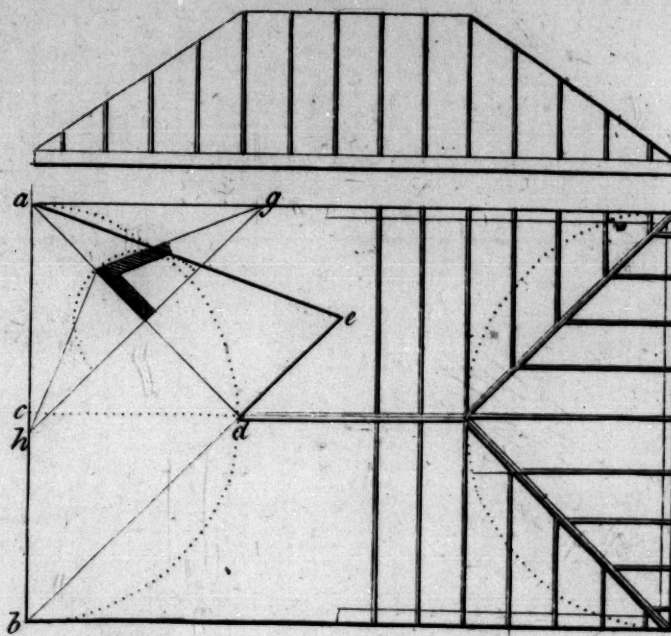


Fig. C.

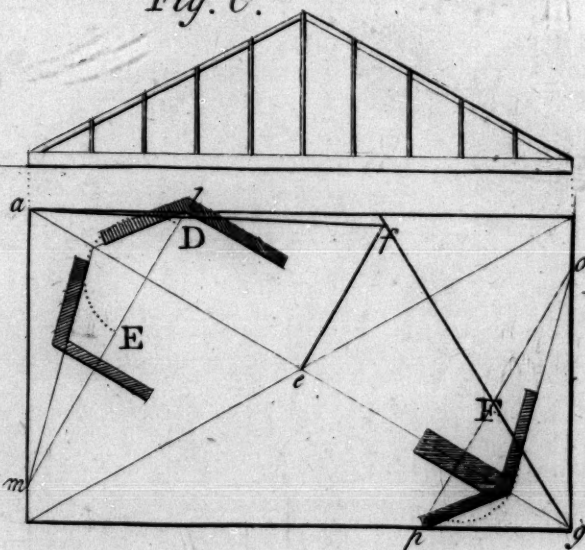


Fig. D.

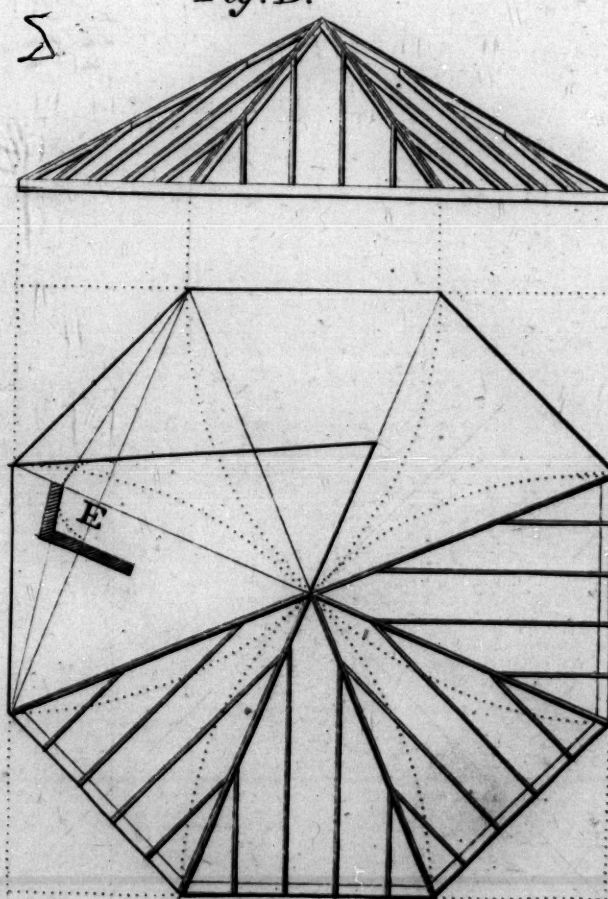
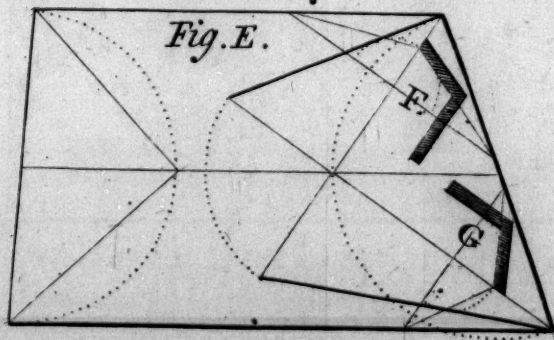


Fig. E.





## P L A T E XXXI.

## S K Y - L I G H T S.

*To find the length of the hips of a sky-light standing upon a square plan, the height being given.*

In *fig. A*, draw the diagonals  $a b$ , and  $c d$ ; they will bisect each other at right angles at  $e$ ; take  $a e$  for the base of any hip; from  $e$  make  $e f$  equal to the height of the sky-light; from  $a$  to  $f$  draw a line  $a f$ , it will be the length of the hip required.

*To find the backing of the hip.*

Draw any line  $k i$ , at right angles to  $a e$ , the base of the hip rafter, to cut it in any point  $h$ , put the foot of your compass in  $h$ , as a centre, and with the other describe a circle to touch  $a f$ , the hip rafter, to cut the base line  $a e$ , at  $g$ ; then draw  $g i$  and  $g k$ ; then the angle  $k g i$  will be the backing of the hip, as is shewn by the bevel at  $B$ ; but the best way to work the hips is to apply a bevel to the parallel sides of the hips, as is shewn at  $C$ , by making the other side of the bevel parallel to  $a e$ , the base of the hip.

*Note.* The same lines will extend to any sky-light, whatever may be the form of its plan; if it be any polygon, to find the length of the hip rafter, draw a line through any point in its base at right angles to it, so as to cut the two contiguous sides to that base, and on the said point as a centre describe a circle to touch the hip rafter from the point where this circle cuts the base line, draw two lines to meet the ends of the perpendicular line at the sides of the polygon; then the angle formed by these two lines will be the backing required: but perhaps a few more examples will make it plainer than many words can.

*FIG. B* is a sky-light, standing upon a rectangular base, having a ridge in the middle; make  $c d$  upon the ridge line equal to half the width of  $a b$ ; then the angle  $b d a$  will be a right angle; every other requisite is the same as directed for *fig. A*; if these hips are to be mitred, the bevel at  $C$  shews the mitre.

*FIG. C* is another sky-light, standing also upon a rectangular base; but the hips all meet over the centre of the plan at  $e$ , and consequently the diagonals do not bisect each other at right angles; therefore take any base line as  $a e$ , or  $e g$ , and make  $e f$  perpendicular to  $a e$ , from  $e$ , and equal to the height of the sky-light; and draw  $f a$ , or  $f g$ , for the length of the hip, by drawing the line  $l m$  at right angles to  $a e$ . The backing will be found in the same manner as the others above. This sky-light will require two different bevels  $D$  and  $E$ , to be applied to the parallel sides of the hip, which are both found from the backing by drawing the stocks of the bevel parallel to  $a e$ , the base of the hip.

But if the hips are to be mitred together,  $F$  and  $G$  shew the two bevels for the mitring each half, so that when put together shall form the proper backing.

*FIG. D* is a sky-light standing upon an octangular plan, as is described in *fig. 8*, plate 6, of the Geometry; the lengths of the hips and backing of the angle are found in the same manner as directed for others.

*FIG. E* is a sky-light whose plan is a trapaziod; upon each end as a diameter describe a semicircle to cut the ridge-line, from these points draw lines to the extremities of their respective diameters, which will form a right angle for the base of the hips to stand upon the backing or mitring of the hips, will be found as is described in *fig. A* and *B*.



## PLATE XXXII.

## LINES FOR ROOFING.

The lines for roofing are found in the same manner as the sky-lights in the last plate; the length and backing of the hip must be found in the same manner as directed for the sky-lights; and if it is required to find the end of a horizontal bar, so that it shall fit against the hip, it will be found in the same manner as finding the form of the end of a purline, so as to fit against the side of a hip rafter, which method will be described below: the same may be said of the jack bars to be fitted against the hip of a sky-light as in a roof.

In this plate one end of the roof is shewn in order to shew two cases: the first is when the purline lies level, or having two sides parallel to the horizon; the square at *B*, and the bevel at *C*, will shew how to draw the end of the purline in this easy case; but the following method is universal in all positions of the purline.

*Note.* There will be no occasion to draw this at large; as the bevels will be the same if done to ever so small a scale, and the sides may be measured from a scale.

Let *ab* be the width of a square roof, make *bf* or *ae* one half of the width, and make *cd* perpendicular in the middle of *ef*, the height of the roof, which is here one third, and draw *de*, and *df*, which are each the length of a common rafter.

*To find the bevels of a purline against the hip rafter.*

Let the purline be in any place of the rafter, as at *I*, and in its most common position, that is, to stand square, or at right angles to the rafter; and from the point *h*, as a centre with any radius, describe a circle. Draw two lines *ql*, and *pn*, to touch the circle in *p* and *q*, parallel to *fb*; and at the points *s* and *r*, where the circle and two sides of the purline intersect, draw two parallel lines to the former, to cut the diagonal in *m* and *k*; and draw *mn* and *kl* perpendicular to *sm* and *rk*, and join the points *ni* and *ki*; then *G* is the down bevel, and *F* the side bevel of a purline: these two bevels, when applied to the end of the purline, and when cut by them, will exactly fit the side hip rafter.

*To find the bevels of a jack rafter against the hip.*

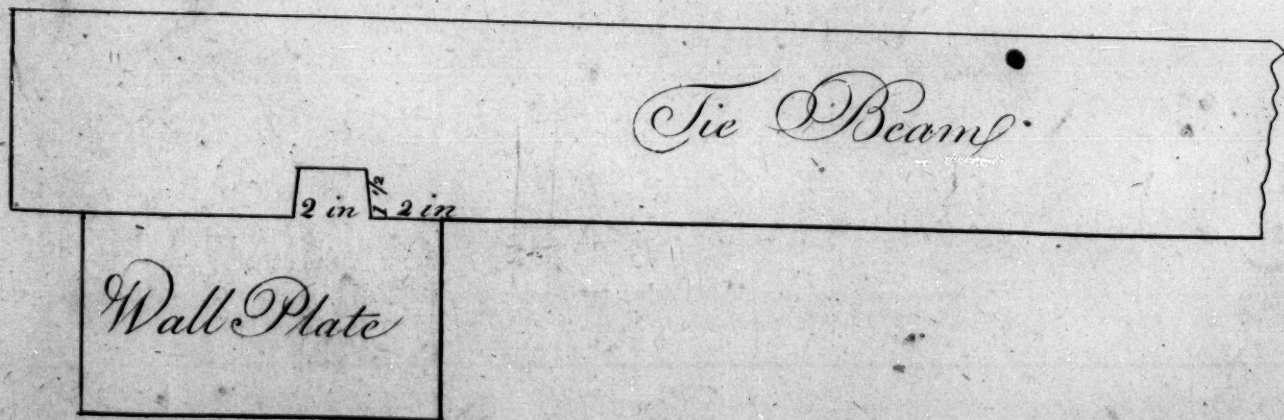
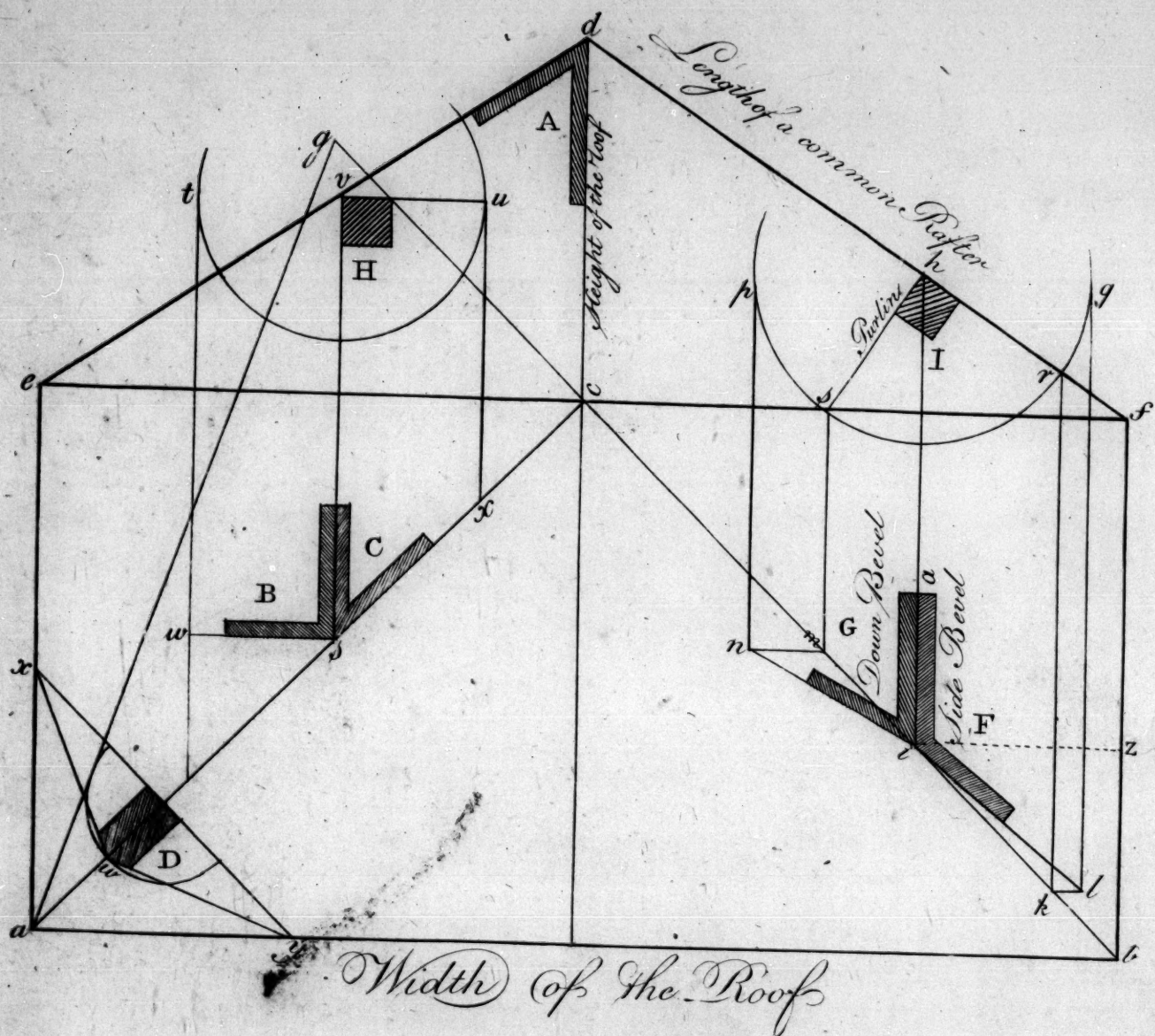
By turning the stock of the side bevel of the purline, at *F*, from *a*, round to the line *iz*, will give the side bevel of the jack rafter. And the bevel at *A*, that is, the top of a common rafter, is the down bevel of the jack rafter.

At the bottom is shewn the manner of cocking down the tie beam upon the wall plate; the proper size of the cocking is figured at *a*.

PLATE



Plate 32.





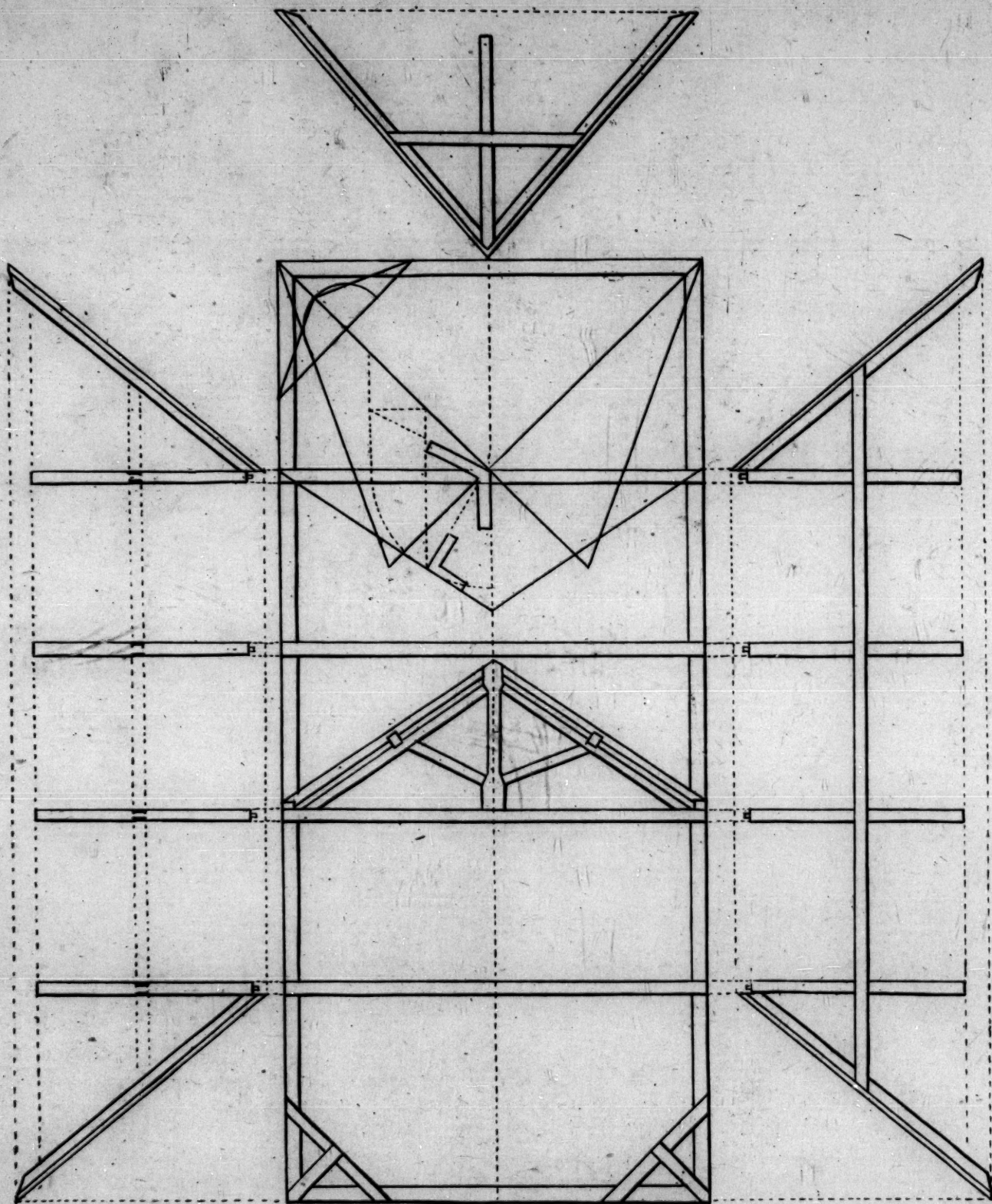








*Plate 33.*

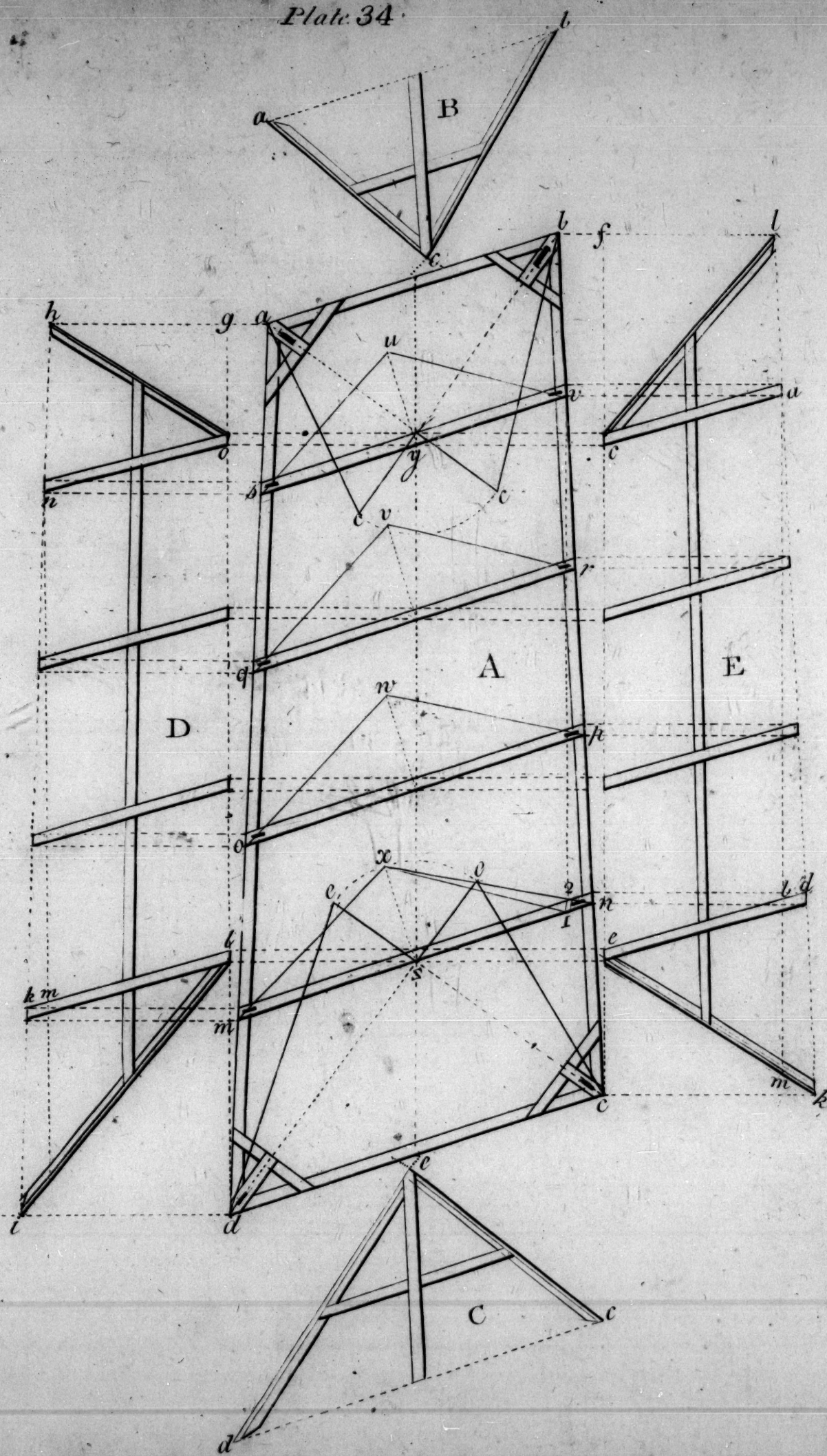


*Pub<sup>d</sup> as the Act directs June 9. 1792 by P. Nicholson.*











## P L A T E XXXIII.

This plate shews the manner of framing a roof in ledgment; but as roofs are seldom executed in this manner, I shall not be very particular in describing its lines. The following description for winding will serve for any.

## P L A T E XXXIV.

*How to lay out an irregular roof in ledgment, with all its beams lying bevel upon the plan, so that the ridge may be level when finished; the plan and height of the room being given.*

The lengths of the common and hip rafters are found as usual. From each side in the broadest end of the roof, through  $c$  and  $d$ , draw two lines parallel to the ridge-line; draw lines from the centres and ends of the beams perpendicular to the ridge-line, and lay out the two sides of the roof  $D$  and  $E$ , by making  $ed$  at  $E$  equal to  $xn$  in  $A$ , the length of the longest common rafter, and  $ca$  in  $E$  equal to  $uv$  at  $A$ , and so on with all the other rafters.

*To find the winding of this roof.*

Take  $yv$ , half the base of the shortest rafter; and apply this to the base of the longest rafter, from  $z$  to  $1$ ; then the distance from  $1$  to  $2$  shews the quantity of winding.

*How to lay the sides in winding.*

Lay a straight beam along the top ends of the rafters at  $E$ , that is, from  $c$  to  $e$ , and lay another beam along the line  $ab$ , parallel to it, to take the ends of the hip rafters at  $m$  and  $l$ , and the beams to be made out of winding at first. Raise the beam that lies from  $a$  to  $b$ , at the point  $b$ , to the distance  $12$  above the level; which beam, being thus raised, will raise all the ends of the rafters gradually, the same as they would be when in their places.

The same is to be understood of the other side  $D$ ; the ends are laid down in the same manner as making a triangle of any three dimensions.

To satisfy the curious, I have given the lines of this roof; but in practice there is not the least occasion for framing the sides in winding, for instead of the ridge-line, the top is made level at the widest end of the roof, from the narrowest end, which begins at a point; and by this means the sides may be framed quite out of winding, which will have a much better effect than any winding roof can have.



## P L A T E XXXV.

## P O L Y G O N R O O F S.

The methods of constructing regular polygons upon any given side, are shewn at fig. 4, 5, and 6, in the Geometry.

*The plan of a polygon roof being given, and one of the common ribs standing upon that plan, to find the angle rib, and the form of the boards that will cover it when the ribs are fitted up.*

In fig. A let  $B$  be the given rib; divide the curve into any number of equal parts, as four, and lay them at  $D$  from  $a$  to  $4$ , which bisects  $b b$ , the side of the polygon, at right angles; through these points draw lines parallel to the side  $b b$  of the polygon; at  $B$  and  $D$  make  $1 c$  at  $D$  equal to  $c c$ , between  $B$  and  $C$   $2 d$  equal to  $d d$ , and  $3 e$  equal to  $e e$ , &c. and through the points  $b, c, d, e, f$ , draw a curve line, which will be the form of the boarding; from the points  $g, f, e, d, c$ , draw lines at right angles to  $g b$ , the base of the angle rib, and pick the rib  $C$  from  $D$  as they are marked by the letters, which is plain.

*Note.* The more parts there is in this operation, the truer it will be, or any other of this nature.

In the same manner may the covering and angle ribs of any other polygon be found, whatever may be the form of the ribs, as is shewn at figures  $B$  and  $C$ .

*To find the covering of a spherical dome.*

FIG. D. Make a circle  $i c k f$ , of the plan of the dome, and if it is a semi-globe take the stretch out of one quarter for the length of a board; make the length of  $K$  from  $a$  to  $4$  equal to it, and let the width  $c c$ , at the bottom, be any thing that the board will admit of; on the base  $c c$ , as a diameter, make a semicircle; divide half the arch-line into any number of equal parts; draw the little lines  $1 1, 2 2, 3 3$ , parallel to  $c c$  the base of the board, and divide the height into the same number of equal parts; draw the ordinates across; make  $1 1, 2 2, 3 3$ , upon these ordinates, equal to  $1 1, 2 2, 3 3$ , in the semicircle at the bottom; a curve being drawn through these points, will be the mould  $K$  for the covering.

*To cover a spherical dome when the top does not rise so high as a semicircle, but only a segment.*

Suppose  $l d$  to be the height of the dome at  $F$ , and the width  $c f$  of the dome as before, upon the chord  $c f$ ; with the perpendicular height  $l d$  describe a segment, which will be the same as a vertical section standing upon  $c f$ ; here is only one half of the segment, which is sufficient; draw the chord  $c d$ ; take  $c a$  equal to half the width of a board, whatever it will admit of; draw  $a b$  perpendicular to cut the chord  $c d$  at  $b$ ; take the stretch or circumference of the arch  $c d$ , and make the length of  $I$  from  $a$  to  $4$  equal to it; take the double of  $a c$ , at  $F$ , and make it the base of the board at  $I$ ; take  $a b$  from  $F$ , and set it upon the base of  $I$ , upon the middle of  $c c$ , from  $a$  to  $b$ ; and with the chord  $c c$ , and the height  $a b$ , describe a segment upon the bottom of the board at  $I$ ; divide one half into any number of equal parts; likewise divide the height of the board  $I$  into the same number of equal parts; draw ordinates in both, and the board  $I$  will be completed, as in the same manner is that of  $H$ , described before.

PLATE



Plate 35.

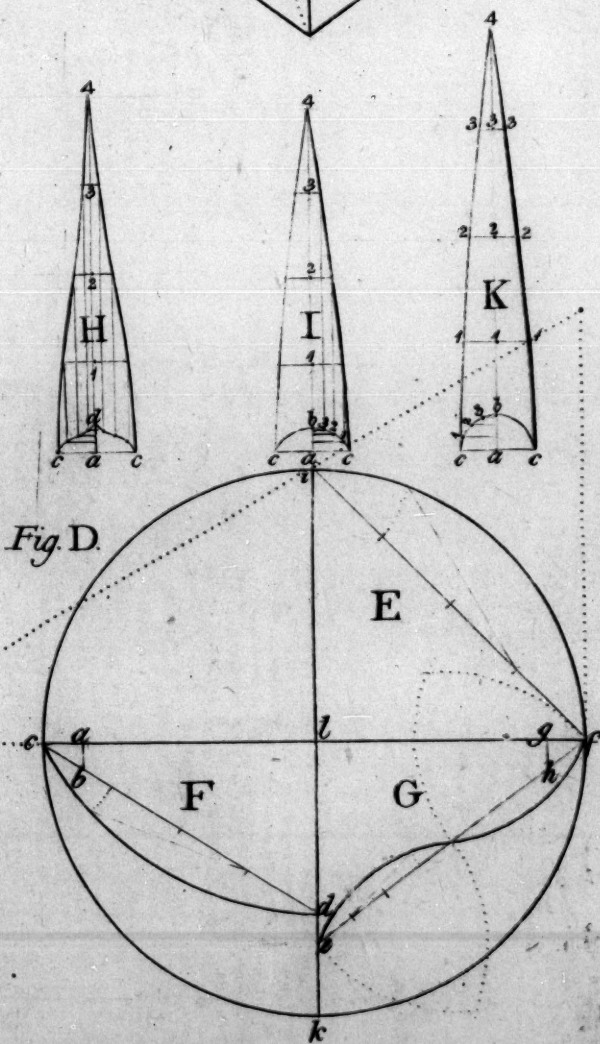
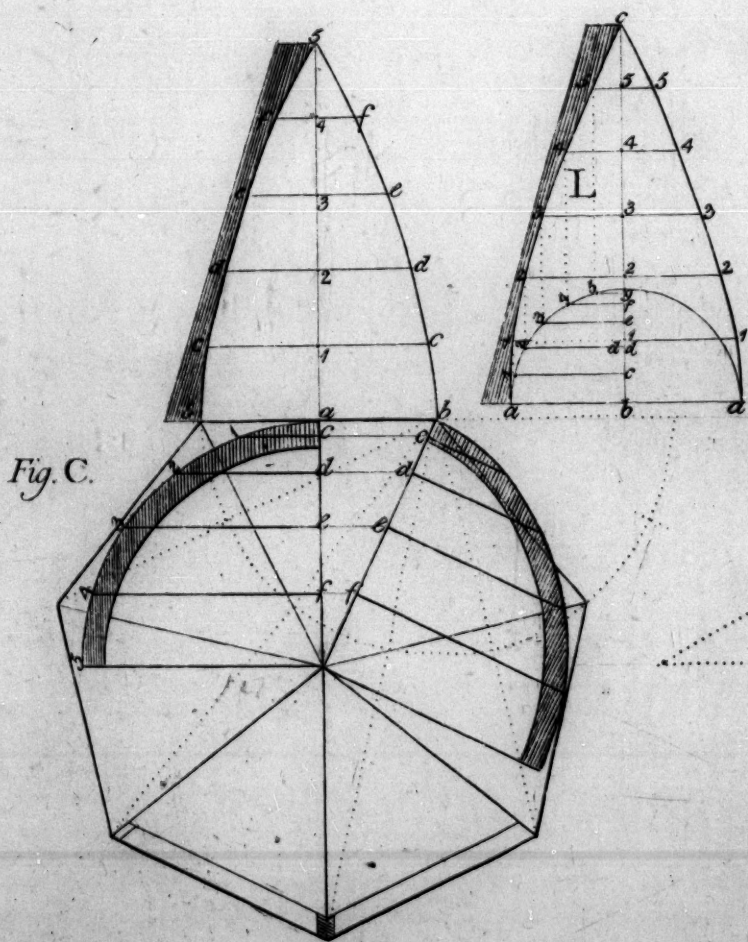
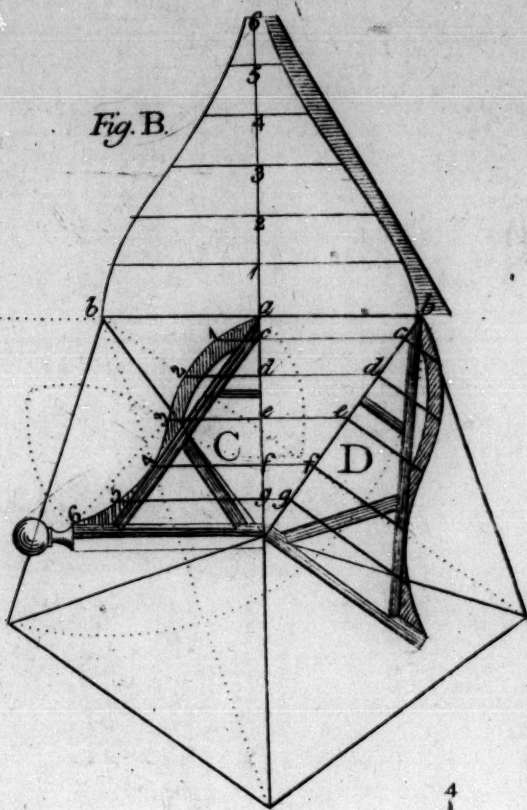
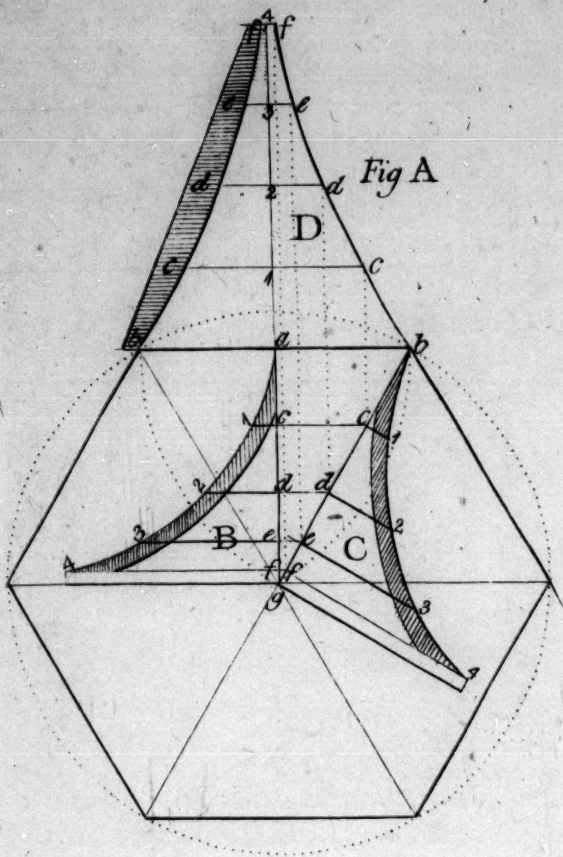




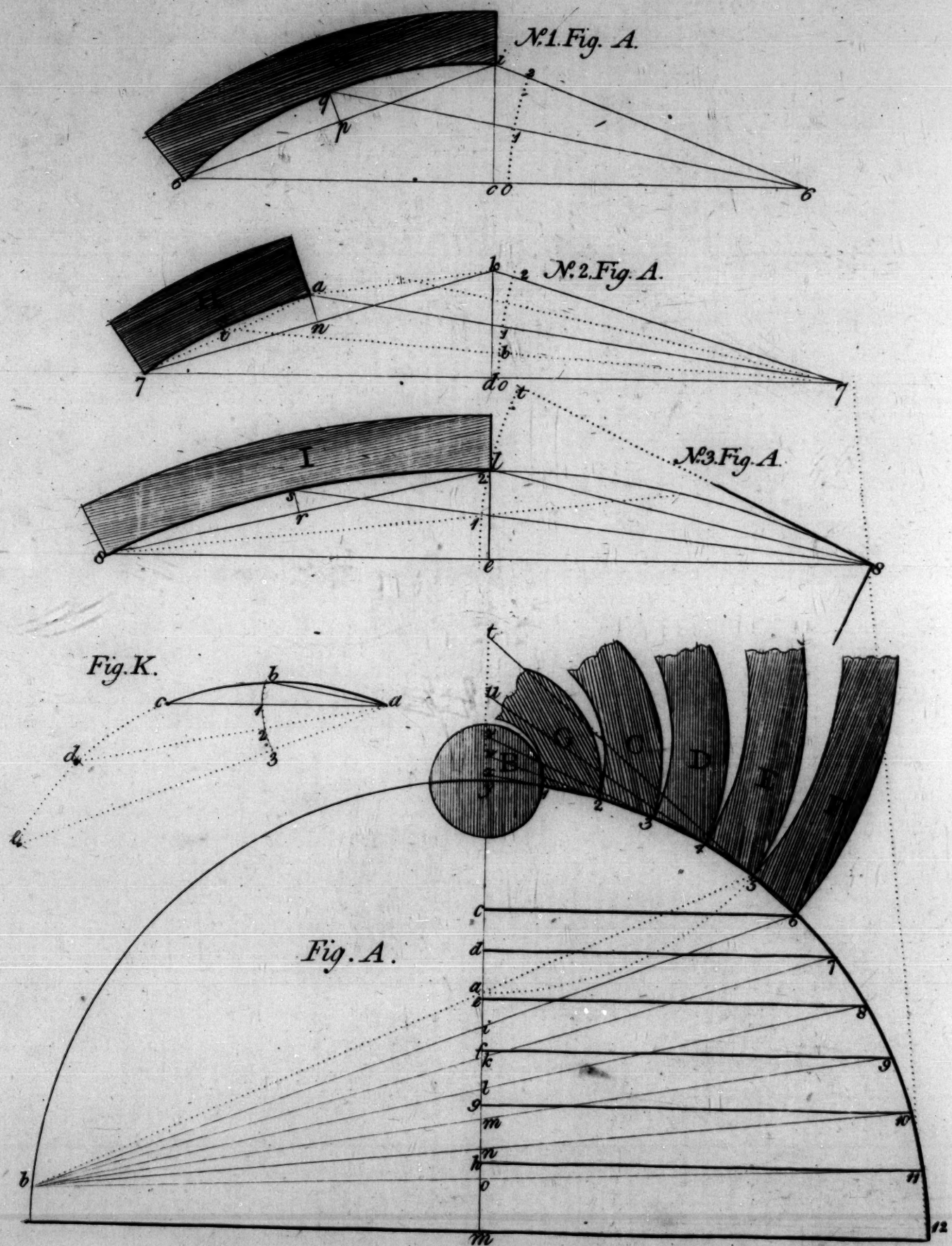








Plate. 36.





## P L A T E XXXVI.

## D O M E S.

As the common method of finding the centres for describing the boards to cover a horizontal dome will be found in practice very inconvenient, for those boards which come near to the bottom; I shall in this place shew how to remedy that inconvenience.

*To find the sweep of the boards at the top. FIG. A.*

Divide round the circumference of the dome into equal parts at 1, 2, 3, 4, 5, 6, &c. each division to the width of a board, making proper allowance for the camber of each board; draw a line through the points 1, 2, to meet the axis of the dome at  $x$ ; on  $x$ , as a centre, with the radii  $x 1$  and  $x 2$  describe the two concentric circles, it will form the board  $G$ ; in the same manner continue a line through the points 2 and 3 at  $C$ , to meet the axis in  $w$ ; then  $w$  is the centre for the board  $C$ ; proceed in the same manner for the boards  $D$ ,  $E$ , and  $F$ .

Now suppose  $F$  to be the last board that you can conveniently find a centre, for want of room; on  $t$  its centre, and the radius  $t 5$ , make from  $t$  on the axis of the dome  $t a$ , equal to  $t 5$ ; through the points 5 and  $a$  draw the dotted line  $5 b$ , to cut the other side of the circumference of the dome at  $b$ ; from the points 6, 7, 8, 9, 10, 11, draw radial lines to  $b$ , to cut the axis of the dome at  $i, k, l, m, n, o$ ; also through the points 6, 7, 8, 9, 10, 11, draw the parallels  $6 c, 7 d, 8 e$ , &c. then will each of these parallel lines be half the length of a chord-line for each board; then take  $c 6$  from *fig. A*, which transfer to No. 1 from  $c$  to 6 and 6; make the height  $c i$ , at No. 1, equal to  $c i$ , at *fig. A*; and draw the chords  $i 6$  and  $i 6$ ; then upon either point 6, as a centre with any radius, describe an arch of a circle  $o 1 2$ ; divide it into two equal parts at 1, and through the points 6 and 1 draw  $6 q$ ; bisect  $i 6$  in  $p$ ; draw  $p q$  perpendicular; then  $i 6$  is the length, and  $p q$  the height of the board  $G$ , which may be described as in *fig. 4*, plate 5, of the Geometry. The reader must observe, that the length of a board is of no consequence so as the true sweep is got, which is all that is required. Proceed in the same manner with No. 2, by taking  $d y$  from *fig. A*, and place it at No. 2, on each side of  $d$  at 7 and 7, and take  $d k$ , from *fig. A*, and make  $d k$  at No. 2, equal to it; draw the chords  $k 7$  and  $k 7$ , and bisect  $k 7$  at  $n$ ; draw  $n a$  perpendicular; upon the other extremity at 7, as a centre, describe an arch  $o 1 2$ , and bisect it at 1, and through the points 7 and 1 draw the line  $7 a$ , to cut the perpendicular  $n a$  at  $a$ ; but if the distance  $k 7$  is too long for the length of a board, bisect the arch  $o 1$  at  $b$ ; through 7 and  $b$  draw  $7 t$ , and draw the little chord  $a 7$ , and bisect it at  $t$ ; draw  $t u$  perpendicular to intersect  $7 a$  at  $u$ ; and with the chord  $7 a$  and the height  $t u$ , describe the segment  $H$ .

In the same manner may the next board  $I$  be found, and by this means you may bring the sweep of your board into the smallest compass, without having any recourse to the centre.

*Suppose it were required to draw a tangent from 8 at No. 3, without having recourse to the centre.*

Bisect the arch  $8 l 8$  at  $l$  on 8, as a centre; with a radius  $8 l$ , describe an arch  $e l t$ ; make  $l t$  equal to  $l e$ ; draw the tangent  $t 8$ .

*Given three points in the circumference of a circle, to find any number of equi-distant points beyond those that will be in the same circumference.*

**FIG. K.** Suppose the three points  $a, b, c$ , to be given to one of the extreme points  $a$ ; join the other two points  $b$  and  $c$  by the lines  $a b$ , and  $a c$ ; with a radius  $a b$ , and the centre  $a$ , describe the arch of a circle  $b 1 2 3$ ; then take  $b 1$  and set it from 1 to 2, and from 2 to 3; through the points 2 and 3, draw  $a d$  and  $a e$ ; then take  $b c$ , put the foot of your compass in  $c$ , and with the other foot cross the line  $a d$  at  $d$ ; with the same extent put the foot of your compass in  $d$ , and with the other foot cross the line  $a e$  at  $e$ ; in the same manner you may proceed for any number of points whatever.



## P L A T E XXXVII.

FIG. *A* is the plan of an elliptical dome; *B* is the longest section, *C* the shortest section; at *a a* in *B*, and *b b* in *C*, shews how to square the purlines, so that one side may be fair with the surface of the dome; the dotted lines from *a a* in *B*, and *b b* in *C*, shews how to get the length and width of the purline in fig. *A*; but if the sides of the purline were made to stand perpendicular over the plan, the sweep of it would be found in the same manner as before; then it would require no more than half the stuff that the other would, and take only half the time in doing, which is a considerable advantage.

*How to proportionate the inside curb for the sky-light, so as it shall answer to the surface of the dome.*

Draw the diagonal *i l* and *k m* in fig. *A*, and let *b e* or *g f* be the width, then *h g* or *e f* will be the true length of the curb; because every section parallel to the base will be proportional to the base of the dome.

*To find the ribs for this dome.*

The ribs in this are got in the same manner as the ribs for a niche, as directed in page 34; and if the reader understands that, he must know this.

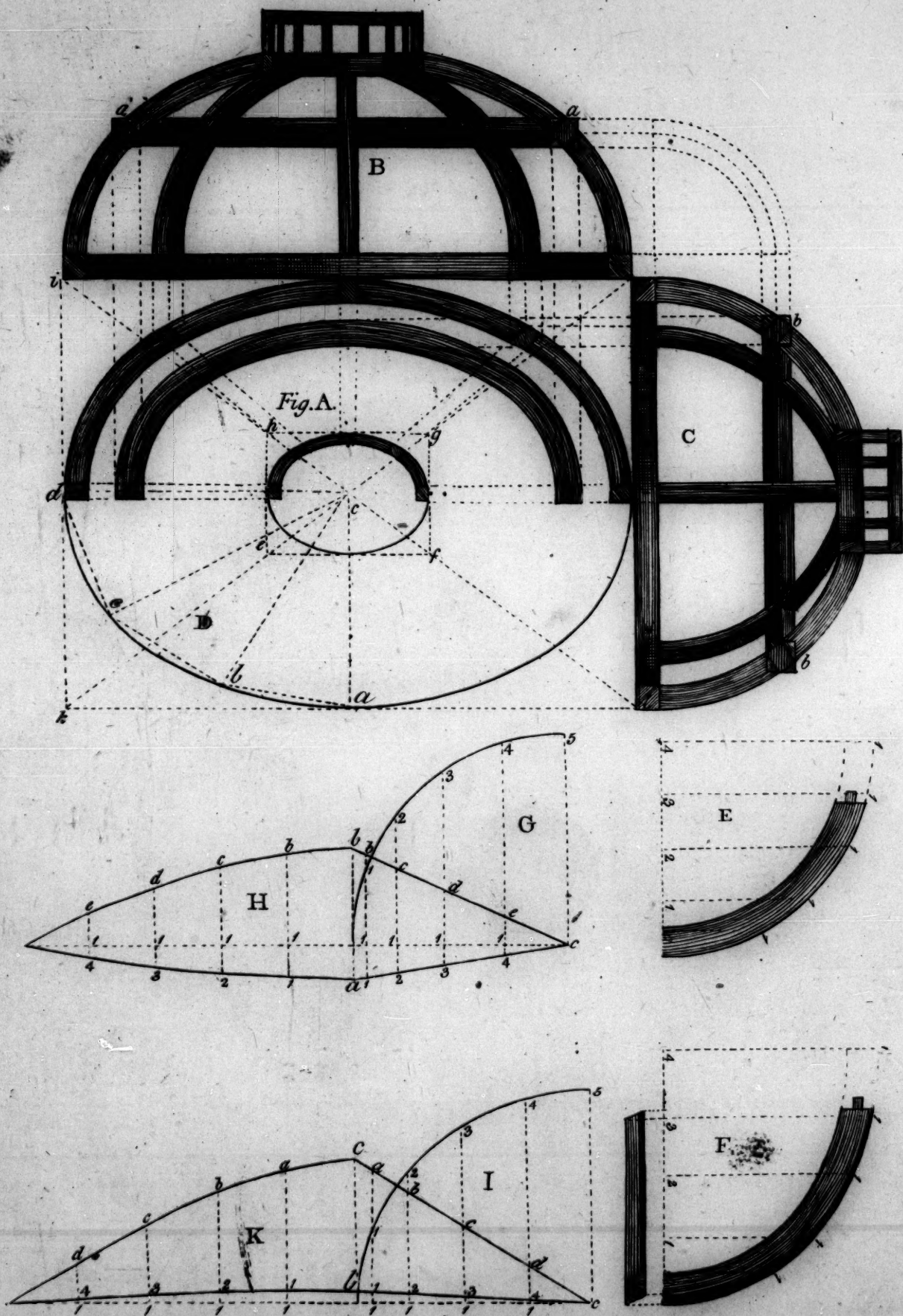
*To find the form of a board to stand in any place of this dome, to be bent up to the crown.*

Suppose you would find a board over *a b c* in the plan; divide *D* into three parts round *a, b, c, d*, and draw *a c, b c, c c*, and *d c*, to the centre at *c*; then take the triangle *a b c* in *D*, and lay it down at *a b c* in *G*; then draw the line *c i i i*, &c. at right angles to *a b*, and describe a rib *G* to the height of the dome, and the length to the perpendicular of the triangle *a b c*, and divide it into five equal parts; lay them along the line *i i i*, &c. in *H*, and prick the mould *H* from the triangle *a b c*, as the letters are marked. The board *K* will be found in the same manner.

*Note.* In the practice, you are to divide one quarter of this dome into as many parts as you think the breadth of a board will contain; and the boards, when got out by this method, will fit to a very great exactness; this is only into three, that the parts may be clearly seen to learners.

If the boards are got out for one quarter of this dome to the lines here laid down, the boards that are in the other three quarters will not require any other lines, for every board in the first quarter will be a mould for three more boards.















Platz 38.

Fig. A.

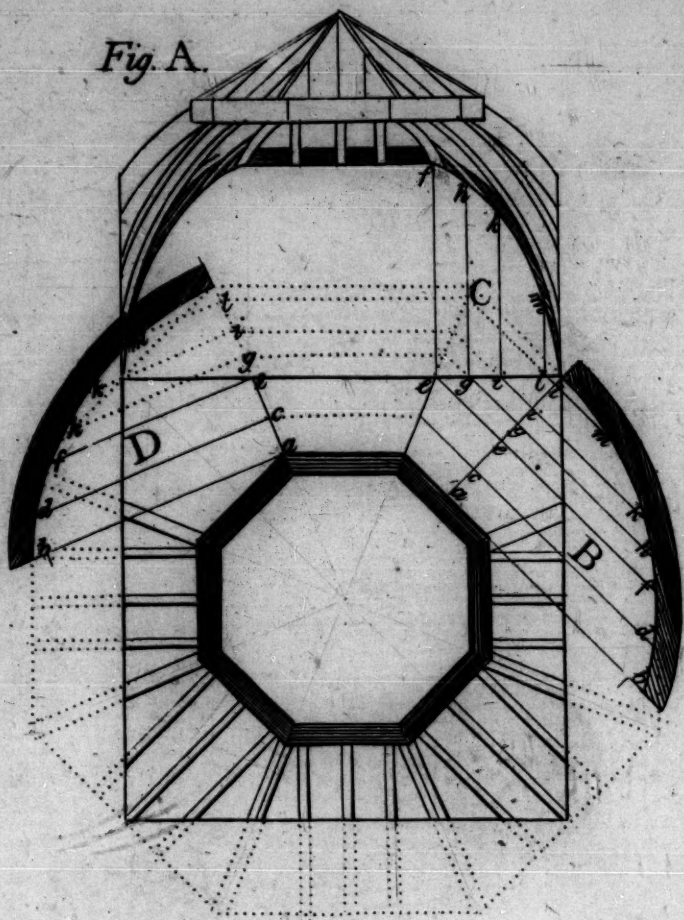


Fig. B.

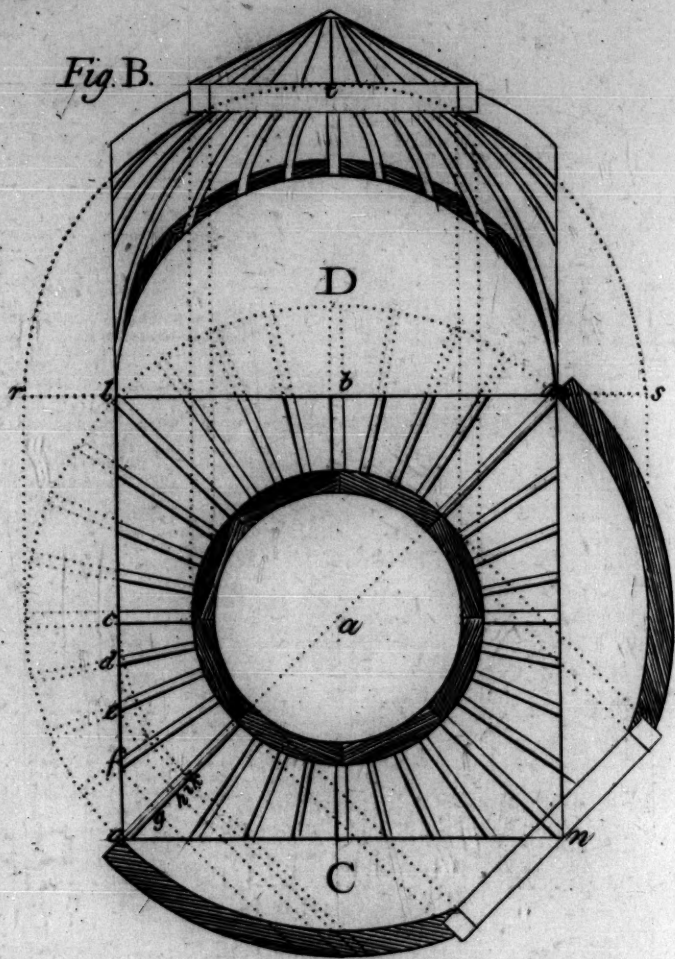


Fig. C.

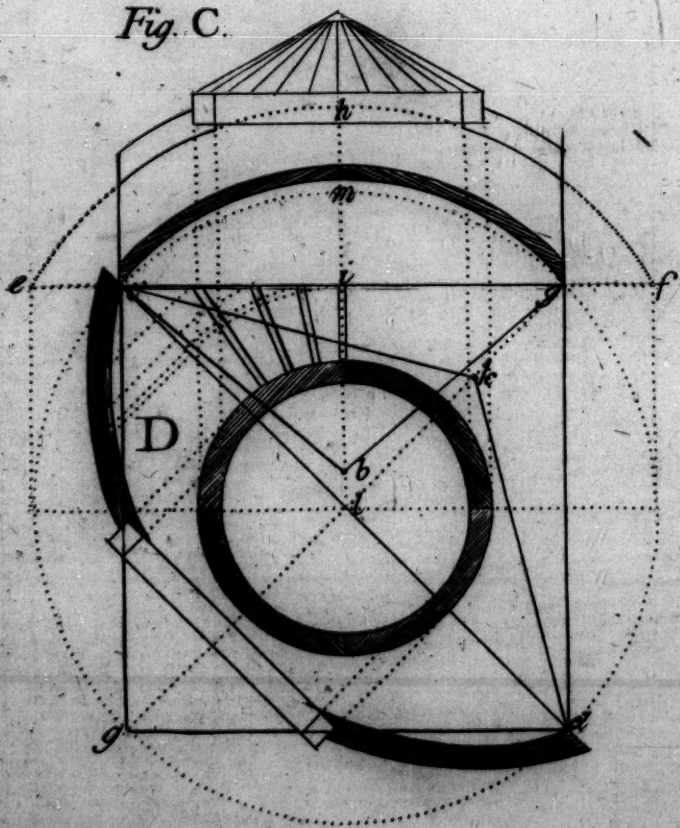
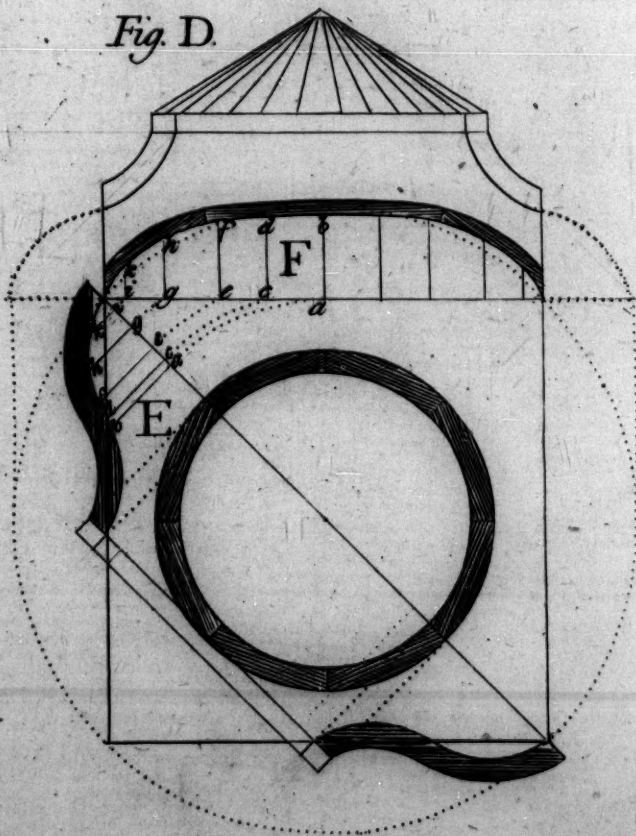


Fig. D.





## P L A T E XXXVIII.

## OF DOMES, WHEN PLACED OVER THE OPENINGS OF STAIR-CASES.

*One of the ribs of a dome being given, and the plan of the opening of a stair-case which is square, and an octagon curb at the top for a sky-light; to find the ribs and the curve on each side of the opening of the stair-case, where the foot of the ribs comes, so that part of the dome shall be an octagon finish, agreeable to the curb.*

**FIG. A.** Let  $B$  be the given rib; take any number of perpendicular ordinates to its base at pleasure; from the points  $a, c, e, g, i, l$ , where they intersect its base, draw parallel lines to the sides of the curb, returning round each diagonal, if there is more than one, till it cut the base of the angle rib  $D$ ; at the points  $a, c, e, g, i, l$ , draw the ordinates of  $D$ , and prick it from  $B$ , will be the angle rib; and at the points  $e, g, i, l$ , at  $C$ , upon the side of the opening of the stair-case, draw the perpendicular ordinates and prick  $C$  from  $B$ , agreeable to the letters; then the curve  $C$  will be the true place for the foot of the ribs upon the side of the stair-case, and the part that lays in the middle is a straight line parallel to the horizon.

*The vertical section of a semicircular dome through its centre being given, the opening of the stair-case being a square as before, to find the curve  $D$  on the side of the stair-case for the foot of the ribs, so that it shall finish to a circular curb at the top.*

On the side of the stair-case  $lm$ , as a diameter, describe a semicircle;  $D$  will be the true place for the foot of the ribs; this is evident, for every section of a semi-globe, at right angles to its base, is a semicircle, and this is the same thing if truly considered.

**Note.** All the ribs of this dome are cut by the rib at  $C$ , as explained by the perpendicular lines; draw round the centre  $a$ , from the points of each bracket, at  $c d e f$ , to the points  $k i h g$ ; from these points draw perpendicular dotted lines, and these will shew what length each bracket must have according to its place.

*The vertical section of a segment dome passing through its centre being given, the plan of the opening of the stair-case being still a square, as before, to find the section upon each side of the stair-case for the foot of the ribs, to finish to a circular curb at the top.*

Let the section  $D$  across the angle be given, whose centre is  $k$ , and the distance of the centre from the chord  $kl$ ; bisect the side of the stair-case by the line  $bh$ , at right angles at the point  $i$ ; from  $i$ , make  $ib$  equal to  $lk$ ; with a radius  $bg$ , or  $bc$ , describe the segment  $c$ ;  $mg$  will be the true place of the foot of the ribs; all the other lesser ribs are cut from the angle rib  $D$ ; all this is evident from the sections of a globe, which is already described in the Geometry.

**FIG. D** is of the same nature as the others, having an ogee top; the section  $F$  is traced from  $E$ .



## P L A T E XXXIX.

FIG. *A* is the plan of an elliptical domical sky-light over a stair-case; *B* and *C* are the sections, which shews how to place your ribs.

*How to proportionate the length of the inside curb to any width given.*

Proceed as directed in page 40 for an elliptical dome, that will determine the true length to the width.

*How to proportionate the circumscribing ellipsis, to pass through the angles at *a*, *b*, *c*, and *d*, to have the same proportion as *a b*, and *b c*, the sides of the stair-case.*

Proceed as directed in fig. 5, plate 6, in the Geometry.

*To describe the ribs.*

The rib over *n* to the centre of the trammel in fig. *A*, is a given quarter of a circle, as is shewn at *F*, and of course all the other ribs must come to the same height with it. Suppose it was required to find a rib over *d p*, you must take the full extent from *d* to the centre, and describe the quarter of an ellipsis *D*; then the part over *d p* will be as much of it as is wanted: in the same manner *E* will be described, and the part over *i o* is what is wanted of this rib; the same letters are marked upon the bases of *D* and *E*, as they are in the plan, fig. *A*. Every other rib is described in the same manner.

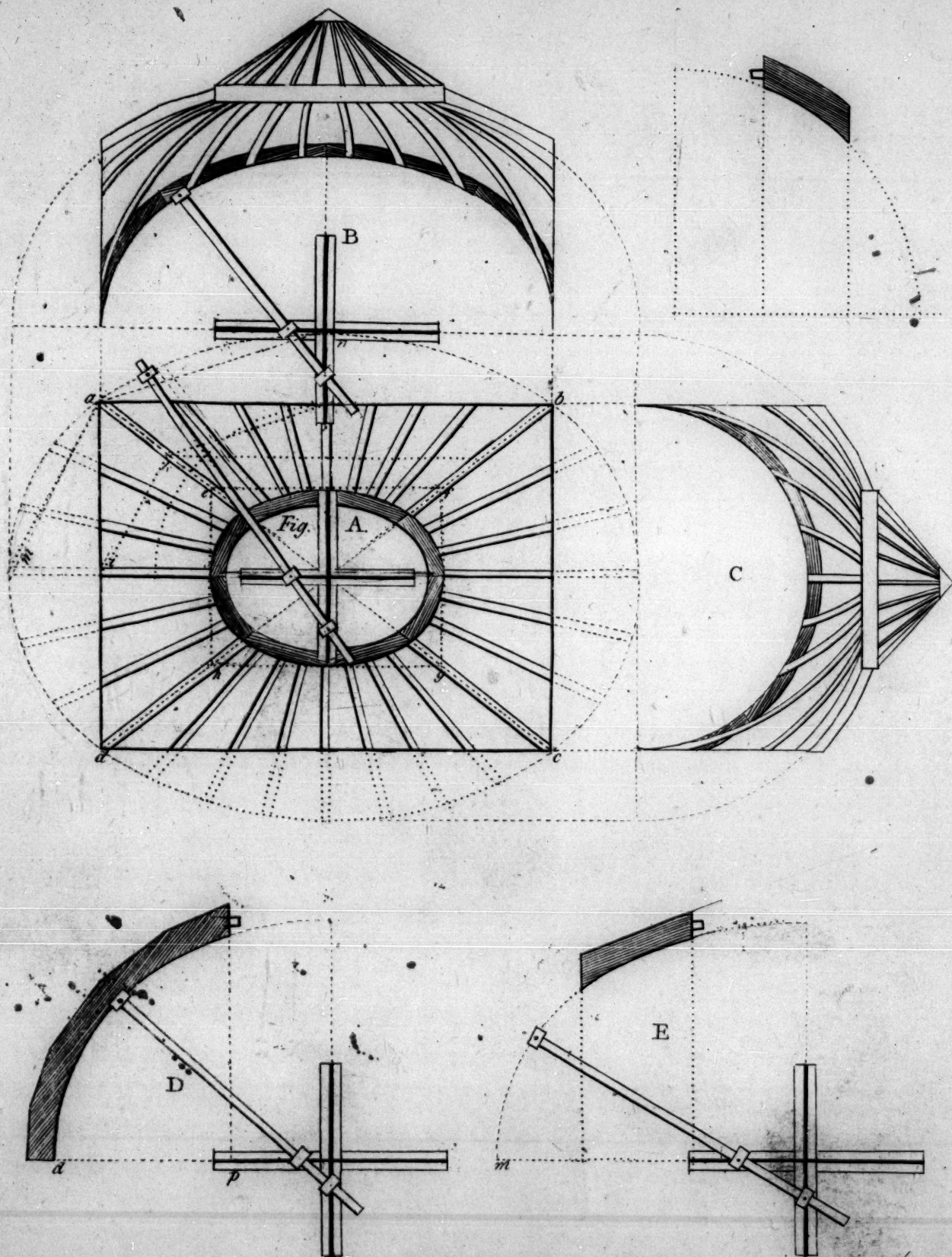
*To find the sections on each side of the stair-case for the foot of the ribs to stand upon.*

Describe the semicircle *C*, to *c b*, the width of the opening of the stair-case, which will give the bottom of the ribs on that side; and describe a quarter of the ellipsis *B*, for the bottom of the ribs on the other side, to the same height as *C*.

This method depends on this principle, that all the parallel sections of a spheroid are similar figures: therefore a vertical section standing upon *a b*, will be similar to a vertical section passing through its centre; both will be similar ellipses: but *a b* is an ordinate to the conjugate axis, and *b c* is an ordinate to the transverse of the circumscribing ellipsis; by construction half the length of the parallelogram is to half the length of the ellipsis, as half the width of the parallelogram is to half the width of the ellipsis, and a spheroid may be supposed to be generated by the revolution of a semi-ellipsis about its axis; hence it follows, that all sections of a spheroid parallel to the axis are similar figures, consequently the section *B* is similar to the circumscribing ellipsis of the ground plan.



Plate 39.



Pub<sup>d</sup> as the Act directs June 27 1792 by P. Nicholson.







INTRODUCTION  
TO  
PRACTICAL CARPENTRY.

---

OF THE COMPARATIVE STRENGTH OF TIMBER.

---

PROPOSITION I.

THE strengths of the different pieces of timber, each of the same length and thickness, are in proportion to the square of the depth; but if the thickness is to be considered along with the depths, then the strengths will be in proportion to the square of the depth, multiplied into the thickness; and if all the three are taken jointly, then the weights that will break each will be in proportion to the square of the depth, multiplied into the thickness, and divided by the length: this is proved by the doctrine of mechanics. Hence a true rule will appear, for proportioning the strength of timbers to one another.

R U L E.

*Multiply the square of the depth of each piece, into its thickness; and each product being divided by their respective lengths, will give the proportional strength of each.*

E X A M P L E.

Suppose three pieces of timber, of the following dimensions:

The first, 6 inches deep, 3 inches thick, and 12 feet long.

The second, 5 inches deep, 4 inches thick, and 8 feet long.

The third, 9 inches deep, 8 inches thick, and 15 feet long. The comparative weight that will break each piece is required.



## OPERATIONS.

| First.        | Second.       | Third.                        |
|---------------|---------------|-------------------------------|
| 6 deep        | 5 deep        | 9 deep                        |
| 6             | 5             | 9                             |
| <hr/>         | <hr/>         | <hr/>                         |
| 36            | 25            | 81                            |
| 3 thick       | 4 thick       | 8 thick                       |
| <hr/>         | <hr/>         | <hr/>                         |
| Length 12)108 | Length 8)100  | Length 15)648(43 and a fifth. |
| <hr/>         | <hr/>         | <hr/>                         |
| 9             | 12 and a half | 60                            |
|               |               | <hr/>                         |
|               |               | 48                            |
|               |               | 45                            |
|               |               | <hr/>                         |
|               |               | 3                             |

Therefore the weights that will break each are nearly in proportion to the numbers 9, 12, and 43, leaving out the fractions, in which you will observe, that the number 43 is almost 5 times the number 9; therefore the third piece of timber will almost bear 5 times as much weight as the first; and the second piece nearly once and a third the weight of the first piece; because the number 12 is once and a third greater than the number 9.

The timber is supposed to be every where of the same texture, otherwise these calculations cannot hold true.

## PROPOSITION II.

Given the length, breadth, and depth of a piece of timber; to find the depth of another piece whose length and breadth are given, so that it shall bear the same weight as the first piece, or any number of times more.

## R U L E.

Multiply the square of the depth of the first piece into its breadth, and divide that product by its length: multiply the quotient by the number of times as you would have the other piece to carry more weight than the first, and multiply that by the length of the last piece, and divide it by its width; out of this last quotient extract the square root, which is the depth required.

## EXAMPLE I.

Suppose a piece of timber 12 feet long, 6 inches deep, 4 inches thick; another piece 20 feet long, 5 inches thick; requireth its depth so that it shall bear twice the weight of the first piece.

6 deep



|                                       |                      |
|---------------------------------------|----------------------|
|                                       | Proof.               |
| 6 deep                                | 9.7                  |
| 6                                     | 9.7                  |
| <hr/>                                 | <hr/>                |
| 36                                    | 67 9                 |
| 4                                     | 873                  |
| <hr/>                                 | <hr/>                |
| 12)144                                | 94.09                |
| 12                                    | 1.91 remainder added |
| 2 times                               | <hr/>                |
| <hr/>                                 | 96.00                |
| 24                                    | 5                    |
| 20 length                             | <hr/>                |
| <hr/>                                 | 20)480               |
| 5)480                                 | <hr/>                |
| <hr/>                                 | 24                   |
| 96(9.7, or 9.8, nearly for the depth. |                      |
| 81                                    |                      |
| <hr/>                                 |                      |
| 187)1500                              |                      |
| 1309                                  |                      |
| <hr/>                                 |                      |
| 191                                   |                      |

EXAMPLE II.

Suppose a piece of timber 14 feet long, 8 inches deep, 3 inches thick; requireth the depth of another piece 18 feet long, 4 inches thick, so that the laft piece fhall bear five times as much weight as the first.

As the length of both pieces of timber is divifible by the number 2, therefore half the length of each is used inftead of the whole; the anfwer will be the fame.

|                              |
|------------------------------|
| 8                            |
| 8                            |
| <hr/>                        |
| 64                           |
| 3                            |
| <hr/>                        |
| half 7)192                   |
| <hr/>                        |
| 27.4, &c.                    |
| 5 times                      |
| <hr/>                        |
| 137                          |
| 9 half the length            |
| <hr/>                        |
| 4)1233                       |
| <hr/>                        |
| 308.25(17.5 the depth nearly |
| <hr/>                        |
| 27)208(                      |
| 189                          |
| <hr/>                        |
| 345) .1925, &c.              |

PROPO-



## PROPOSITION III.

Given the length, breadth, and depth of a piece of timber; to find the breadth of another piece whose length and depth is given, so that the last piece shall bear the same weight as the first piece, or any number of times more.

## R U L E.

Multiply the square of the depth of the first piece into its thickness; that divided by its length, multiply the quotient by the number of times as you would have the last piece bear more than the first; that being multiplied by the length of the last piece, and divided by the square of its depth, this last quotient will be the breadth required.

## EXAMPLE I.

Given a piece of timber 12 feet long, 6 inches deep, 4 inches thick; and another piece 16 feet long, 8 inches deep; requireth the thickness, so that it shall bear twice as much weight as the first piece.

Or this, at full length.

$$\begin{array}{r}
 6 \\
 6 \\
 \hline
 36 \\
 4 \\
 \hline
 3)144 \\
 \hline
 48 \\
 2 \\
 \hline
 96 \\
 4 \\
 \hline
 8)384 \\
 \hline
 8)48 \\
 \hline
 6 \text{ thickness.}
 \end{array}$$

$$\begin{array}{r}
 6 \text{ depth of the first piece} \\
 6 \\
 \hline
 36 \\
 4 \text{ thickness of the first piece} \\
 \hline
 \text{Length } 12)144 \\
 \hline
 12 \\
 2 \text{ by the number of times stronger} \\
 \hline
 24 \\
 16 \text{ length of the last piece} \\
 \hline
 144 \\
 24 \\
 \hline
 8)384 \\
 \hline
 8)48 \\
 \hline
 6 \text{ thickness.}
 \end{array}$$

EXAMPLE



## EXAMPLE II.

Given a piece of timber 12 feet long, 5 inches deep, 3 inches thick; and another piece 14 feet long, 6 inches deep; requireth the thickness, so that the last piece may bear four times as much weight as the first piece.

$$\begin{array}{r}
 5 \\
 5 \\
 \hline
 25 \\
 3 \\
 \hline
 12 \overline{) 75} \\
 \underline{6.25} \\
 4 \\
 \hline
 25.00 \\
 14 \\
 \hline
 100 \\
 25 \\
 \hline
 6 \overline{) 350} \\
 \hline
 6 \overline{) 58.266} \\
 \hline
 9.788
 \end{array}$$

## PROPOSITION IV.

If the stress does not lay in the middle of the timber, but nearer to one end than the other, the strength in the middle will be to the strength in any other part of the timber, as 1 divided by the square of half the length is to 1 divided by the rectangle of the two segments, which are parted by the weight.

## EXAMPLE I.

Suppose a piece of timber 20 feet long, the depth and width is immaterial; suppose the stress or weight to lay five feet distant from one of its ends, consequently from the other end 15 feet, then the above proportion will be  $\frac{1}{10 \times 10} = \frac{1}{100} : \frac{1}{5 \times 15} = \frac{1}{75}$  as the strength at 5 feet from the end is to the strength at the middle, or 10 feet, or as  $\frac{100}{100} = 1 : \frac{100}{75} = 1 \frac{1}{3}$ .

Hence it appears, that a piece of timber 20 feet long is one third stronger at 5 feet distance from the bearing, than it is in the middle, which is 10 feet, when cut in the above proportion.

EXAMPLE



## EXAMPLE II.

Suppose a piece of timber 30 feet long; let the weight be applied 4 feet distant from one end, or more properly from the place where it takes its bearing, then from the other end it will be 26 feet, and the middle is 15 feet; then  $\frac{1}{15 \times 15} = \frac{1}{225} : \frac{1}{4 \times 26} = \frac{1}{104}$  or as  $\frac{225}{104}$   
 $= 1 : \frac{225}{104} = 2 \frac{17}{104}$  or nearly  $2 \frac{1}{6}$ .

Hence it appears, that a piece of timber 30 feet long will bear double the weight, and one sixth more, at 4 feet distant from one end, than it will do in the middle, which is 15 feet distant.

## EXAMPLE III.

Allowing that 266 pounds will break a beam 26 inches long, requireth the weight that will break the same beam when it lays at 5 inches from either end; then the distance to the other end is 21 inches;  $21 \times 5 = 105$ , the half of 26 inches is 13  $\therefore 13 \times 13 = 169$ ; therefore the strength at the middle of the piece is to the strength at 5 inches from the end, as  $\frac{169}{169} : \frac{169}{105}$  or as  $1 : \frac{169}{105}$  the proportion is stated thus:

$$\begin{array}{r}
 \text{lb.} \\
 1 : \frac{169}{105} :: 266 : \text{to the weight required;} \\
 \hline
 169 \\
 2394 \\
 1596 \\
 266 \\
 \hline
 105)44954(428 \\
 \underline{420} \\
 295 \\
 \underline{270} \\
 854 \\
 \underline{840} \\
 .14
 \end{array}$$

From this calculation it appears, that rather more than 428 pounds will break the beam at 5 inches distant from one of its ends, if 266 pounds will break the same beam in the middle.

By similar propositions the scantlings of any timber may be computed, so that they shall sustain any given weight; for if the weight one piece will sustain be known, with its



its dimensions, the weight that another piece will sustain, of any given dimensions, may also be computed. The reader must observe, that although the foregoing rules are mathematically true, yet it is impossible to account for knots, cross-grained wood, &c. such pieces being not so strong as those which are straight in the grain; and if care is not taken in choosing the timber for a building, so that the grain of the timbers runs nearly equal to one another, all rules which can be laid down will be baffled, and consequently all rules for just proportion will be useless in respect to its strength. It will be impossible, however, to estimate the strength of timber fit for any building, or to have any true knowledge of its proportions, without some rule; as without a rule every thing must be done by mere conjecture.

Timber is much weakened by its own weight, except it stand perpendicular, which will be shewn in the following problems; if a mortice is to be cut in the side of a piece of timber, it will be much less weakened when cut near the top, than it will be if cut at the bottom, provided the tenent is drove hard in to fill up the mortice.

The bending of timber will be nearly in proportion to the weight that is laid on it; no beam ought to be trusted for any long time with above one third or one fourth part of the weight it will absolutely carry; for experiment proves, that a far less weight will break a piece of timber when hung to it for any considerable time, than what is sufficient to break it when first applied.

## P R O B L E M I.

Having the length and weight of a beam that can just support a given weight, to find the length of another beam of the same scantling, that shall just break with its own weight:

Let  $l$  = the length of the first beam,

$L$  = the length of the second;

$a$  = the weight of the first beam,

$w$  = the additional weight that will break it.

And because the weights that will break beams of the same scantling are reciprocally as their lengths,

therefore  $\frac{1}{l} : \frac{1}{L} :: w + \frac{a}{2} : \frac{\overline{w + \frac{a}{2}} \times l}{L} = W$  = the weight that will break the greater beam;

because  $w + \frac{a}{2}$  is the whole weight that will break the lesser beam.

But the weights of beams of the same scantling are to one another as their lengths:

Whence,  $l : L :: \frac{a}{2} : \frac{L a}{2 l} = W$  half the weight of the greater beam.

Now the beam cannot break by its own weight, unless the weight of the beam be equal to the weight that will break it:

Wherefore,  $\frac{L a}{2 l} = \frac{\overline{w + \frac{a}{2}} \times l}{L} = \frac{2 w + a}{2 L} \times l$   
 $L^2 a = 2 w + a \times l^2$

Whence,  $a : 2 w + a :: l^2 : L^2$ , consequently  $\sqrt{L^2} = L$  = the length of the beam that can just sustain its own weight.

H

PROBLEM



## PROBLEM II.

Having the weight of a beam that can just support a given weight in the middle; to find the depth of another beam similar to the former, so that it shall just support its own weight.

Let  $d$  = the depth of the first beam;

$x$  = the depth of the second beam;

$a$  = the weight of the first beam;

$w$  = the additional weight that will break the first beam:

then will  $w + \frac{a}{2}$  or  $\frac{2w+a}{2}$  = the whole weight that will break the lesser beam:

And because the weights that will break similar beams are as the squares of their lengths;

$$\therefore d^2 : x^2 :: \frac{2w+a}{2} : \frac{2x^2w+x^2a}{2d^2} = W$$

the weights of similar beams are as the cubes of their corresponding sides:

$$\text{Hence } d^3 : x^3 :: \frac{a}{2} : \frac{ax^3}{2d^3} = W$$

$$\therefore \frac{ax^3}{2d^3} = \frac{2x^2w+x^2a}{2d^2}$$

$$ax = 2w + a \times d$$

$$\therefore a : a + 2w :: d : x = \text{the depth required.}$$

As the weight of the lesser beam is to the weight of the lesser beam, together with the additional weight; so is the depth of the lesser beam, to the depth of the greater beam.

*Note.* Any other corresponding sides will answer the same purpose, for they are all proportional to one another.

## EXAMPLE.

Suppose a beam whose weight is one pound, and its length 10 feet, to carry a weight of 399.5 pounds, requireth the length of a beam similar to the former, of the same matter, so that it shall break with its own weight:

$$\text{then } a = 1$$

$$\text{and } a + 2w = 800$$

$$d = 10$$

Then by the last problem it will be

$$1 : 800 :: 10$$

$$10$$

$$8000 = x \text{ for the length of a beam that will break by its own weight.}$$



## P R O B L E M III.

The weight and length of a piece of timber being given, and the additional weight that will break it, to find the length of a piece of timber similar to the former, so that this last piece of timber shall be the strongest possible :

Put  $l$  = the length of the piece given,

$w$  = half its weight,

$W$  = the weight that will break it ;

$x$  = the length required.

then, because the weights that will break similar pieces of timber are in proportion to the squares of their lengths,

$$\therefore l^2 : x^2 :: W + w : \frac{Wx^2 + wx^2}{l^2} = \text{the whole weight that breaks the beam ;}$$

and because that the weights of similar beams are as the cubes of their lengths, or any other corresponding sides,

$$\text{then } l^3 : x^3 :: w : \frac{wx^3}{l^3} \text{ the weight of the beam ;}$$

$$\text{consequently } \frac{Wx^2 + wx^2}{l^2} - \frac{wx^3}{l^3} \text{ is the weight that breaks the beam} = a$$

maximum ; therefore its fluxion is nothing,

$$\text{that is, } 2Wx\dot{x} + 2wx\dot{x} - \frac{3wx^2\dot{x}}{l} = \text{nothing.}$$

$$2W + 2w = \frac{3wx}{l}$$

$$\text{hence, } x = l \times \frac{2W + 2w}{3w}$$

Hence it appears from the foregoing problems, that large timber is weakened in a much greater proportion than small timber, even in similar pieces, therefore a proper allowance must be made for the weight of the pieces, as I shall here shew by an example.

Suppose a beam 12 feet long, and a foot square, whose weight is 3 hundred weight, to be capable of supporting 20 hundred weight, what weight will a beam 20 feet long, 15 inches deep, and 12 thick, be able to support ?

|                  |           |
|------------------|-----------|
| 12 inches square | 15        |
| 12               | 15        |
| 144              | 75        |
| 12               | 15        |
| 12)1728          | 225       |
| 144              | 12        |
|                  | 2.0)270.0 |
|                  | 135       |

H 2

But



But the weight of both beams are as their solid contents ;

therefore, 12 inches square  
12

144  
144 inches = 12 feet long  
576  
576  
144

20736 solid contents of the 1st beam.

15 deep  
12 wide.

180  
240 length in inches

7200  
360

43200 solid contents of the 2d beam.

20736 : 43200 :: 3  
3

20736) 129600 (6... cwt.  
124416

..5184  
112

10368  
5184  
5184

20736) 580608 (28  
41472

165888  
165888  
.....

144 : 135 :: 21.5 by prop. 1.  
21.5

67 5  
135  
270

12) 2902.5

12) 241.875

20.15625  
112

31250  
15625  
15625

17,50000  
16

30  
5

8,0

21 cwt. 56 lb. is the weight that will break the first beam, and 20 cwt. 17 lb. 8 oz. the weight that will break the second beam ; deduct out of these half their own weight.

20..17..8  
3..14..0 half  
17...3..8

Now 20 cwt. is the additional weight that will break the first beam ; and 17 cwt. 3 lb. 8 oz. the weight that will break the second : In which the Reader will observe, that 17..3..8 has a much less proportion to 20, than 20 cwt. 17 lb. 8 oz. has to 21..56. From these examples the Reader may see that a proper allowance ought to be made for all horizontal beams ; that is, half the weights of beams ought to be deducted out of the whole weight that they will carry, and that will give the weight that each piece will bear.



If several pieces of timber of the same scantling and length are applied one above another, and supported by props at each end, they will be no stronger than if they were laid side by side; or this, which is the same thing, the pieces that are applied one above another are no stronger than one single piece whose width is the width of the several pieces collected into one, and its depth the depth of one of the pieces; it is therefore useless to cut a piece of timber lengthways, and apply the pieces so cut one above another, for these pieces are not so strong as before, even if bolted.

## E X A M P L E.

Suppose a girder 16 inches deep, 12 inches thick, the length is immaterial, and let the depth be cut lengthways in two equal pieces; then will each piece be 8 inches deep, and 12 inches thick. Now, according to the rule of proportioning timber, the square of 16 inches, that is, the depth before it was cut, is 256, and the square of 8 inches is 64; but twice 64 is only 128, therefore it appears that the two pieces applied one above another is but half the strength of the solid piece, because 256 is double 128.

If a girder be cut lengthways in a perpendicular direction, the ends turned contrary, and then bolted together, it will be but very little stronger than before it was cut; for although the ends being turned give to the girder an equal strength throughout, yet wherever a bolt is, there the girder will be weaker, and I am very doubtful whether it will be any stronger for this process of sawing and bolting; and I say this from experience.

If there are two pieces of timber of an equal scantling (Pl. 52, *fig. B*), the one lying horizontal and the other inclined, the horizontal piece being supported at the points *e* and *f*, and the inclined piece at *c* and *d*, perpendicularly over *e* and *f*, according to the principles of mechanics, these pieces will be equally strong. But, to reason a little on this matter, let it be considered that although the inclined piece *D* is longer; yet the weight has less effect upon it when placed in the middle, than the weight at *b* has upon the horizontal piece *C*, the weights being the same; it is therefore reasonable to conclude, that in these positions the one will bear equal to the other.

The foregoing rules will be found of excellent use when timber is wanted to support a great weight; for, by knowing the superincumbent weight, the strength may be computed to a great degree of exactness, so that it shall be able to support the weight required. The consequence is as bad when there is too much timber, as when there is too little, for nothing is more requisite than a just proportion throughout the whole building, so that the strength of every part shall always be in proportion to the stress; for when there is more strength given to some pieces than others, it encumbers the building, and consequently the foundations are less capable of supporting the superstructure.

No judicious person, who has the care of conducting buildings, should rely on tables of scantlings, such as are commonly in books; for example, in story posts the scantlings, according to several authors, are as follows:

|     |             |                 |
|-----|-------------|-----------------|
| For | 9 feet high | 6 inches square |
| 12  | —           | 8               |
| 15  | —           | 10              |
| 18  | —           | 12              |

Now,



Now, according to this table, the scantlings are increased in proportion to the height; but there is no propriety in this, for each of these will bear weight in proportion to the numbers 9, 16, 25, and 36, that is, in proportion to the square of their heights, 36 being 4 times 9; therefore the piece that is 18 feet long, will bear four times as much weight as that piece which is 9 feet long; but the 9 feet piece may have a much greater weight to carry than an eighteen feet piece, suppose double, in this case it must be near 12 inches square instead of 6. The same is also to be observed in breast-summers, and in floors where they are wanted to support a great weight; but in common buildings, where there is only customary weights to support, the common tables for floors will be near enough for practice.

To conclude the subject, it may be proper to notice the following observations which several authors have judiciously made, viz. that in all timber there is moisture, wherefore all bearing timber ought to have a moderate camber or roundness on the upper side, for till that moisture is dried out the timber will swag with its own weight.

But then observe, that it is best to truss girders when they are fresh sawn out, for by their drying and shrinking, the trusses become more and more tight.

That all beams or ties be cut, or in framing forced to a roundness such as an inch in twenty feet length, and that principal rafters also be cut or forced in framing, as before; because all joists, though ever so well framed, by the shrinking of the timber and weight of the covering will swag, sometimes so much as not only to be visible, but to offend the eye; by this precaution the truss will always appear well.

Likewise observe, that all case bays either in floors or roofs do not exceed twelve feet if possible, that is, do not let your joists in floors exceed twelve feet, nor your purlines in roofs, &c. but rather let their bearing be eight, nine, or ten feet; this should be regarded in forming the plan.

Also, in bridging floors, do not place your binding or strong joist above three, four, or five feet apart, and that your bridging or common joists are not above ten or twelve inches apart, that is, between one joist and another.

Also, in fitting down tie beams upon the wall plates, never to make your cocking too large, nor yet too near the outside of the wall plate, for the grain of the wood being cut across in the tie beam, the piece that remains upon its end will be apt to split off, but keeping it near the inside will tend to secure it. See plate 32, at the bottom, where the dimensions are figured.

Likewise observe, never to make double tenents for bearing uses, such as binding joists, common joists, or purlines; for, in the first place, it very much weakens whatever you frame it into, and in the second place it is a rarity to have a draught in both tenents, that is, to draw both joints close, for the pin in passing through both tenents, if there is a draught in each, will bend so much that, without it is as tough as wire, it must needs break in driving, and consequently do more hurt than good.

Roofs will be much stronger if the purlines are notched above the principal rafters, than if they are framed into the side of the principals; for by this means, when any weight is applied in the middle of the purline it cannot bend, being confined by the other rafters, and if it do, the sides of the other rafters must needs bend along with it, consequently it has the strength of all the other rafters side-ways added to it.







Plate 40.

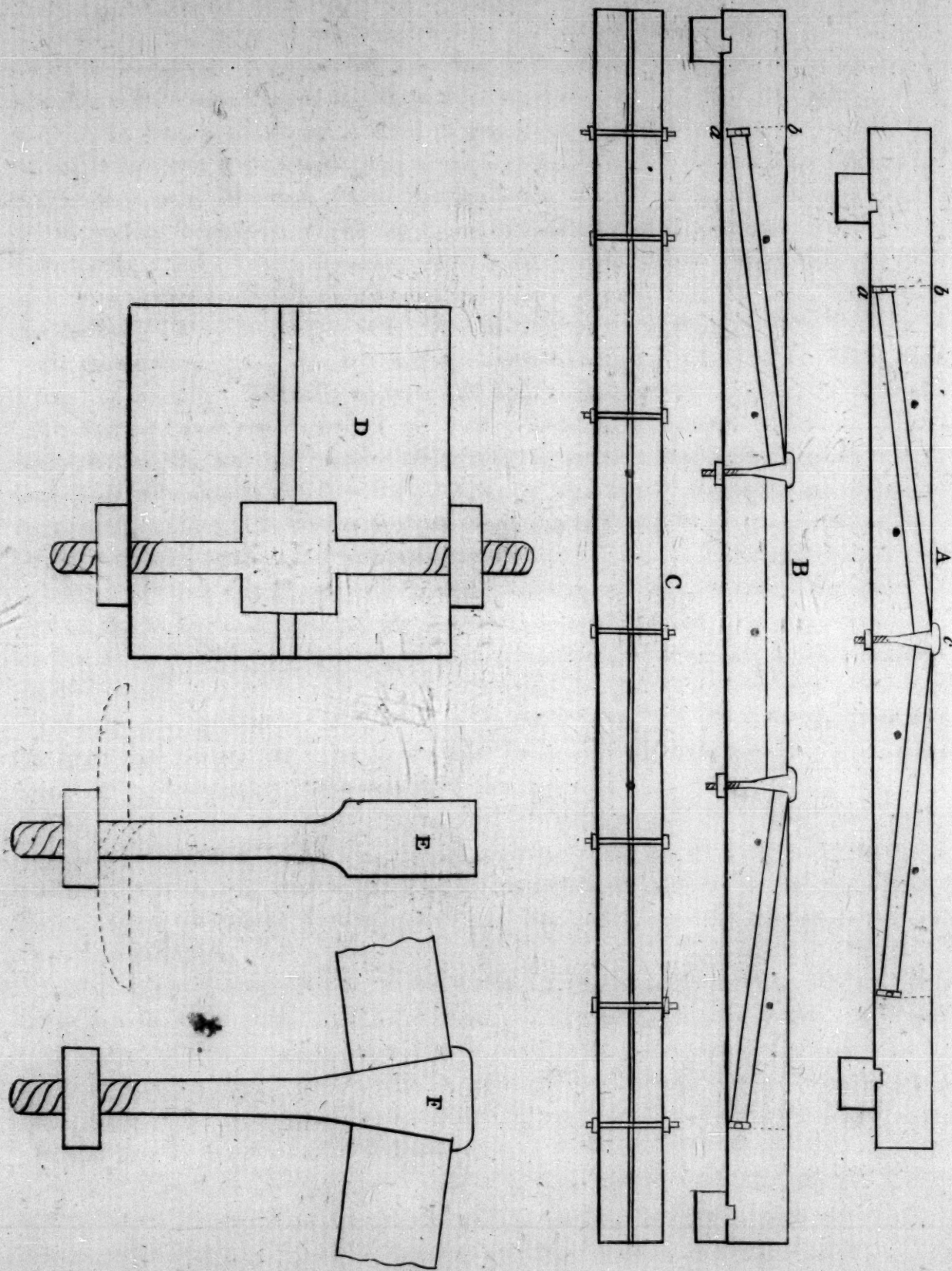








Plate 41.

Fig. A.

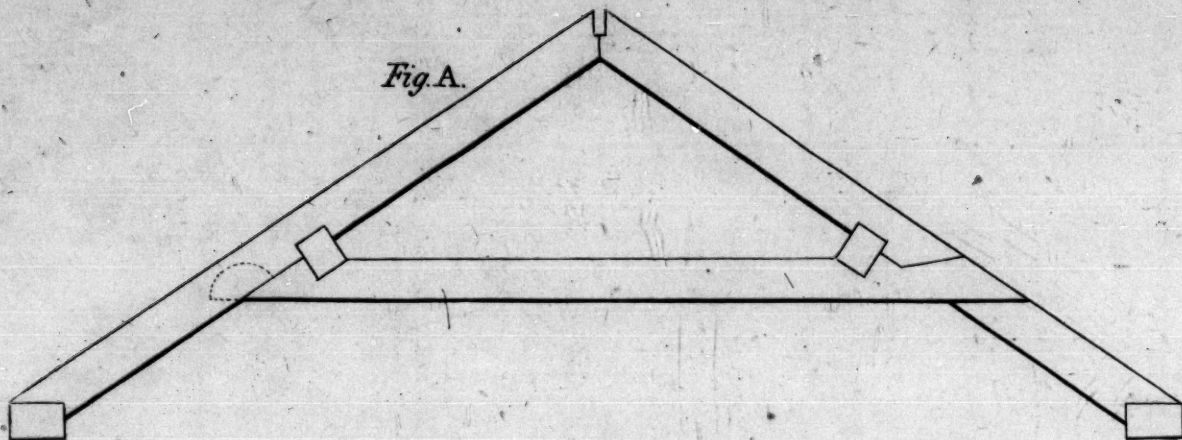


Fig. B.

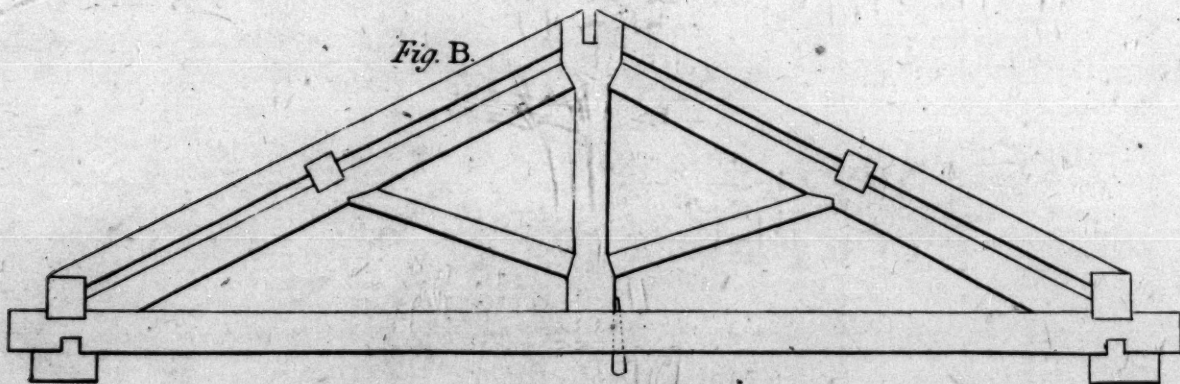
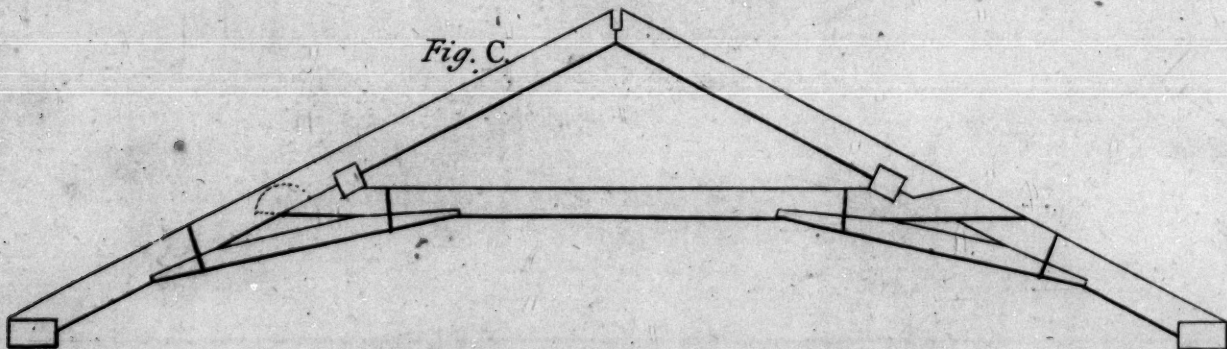


Fig. C.



Pub<sup>d</sup> as the Act directs June 8. 1792 by P. Nicholson.



# PRACTICAL CARPENTRY.

---

## PLATE XL.

*A* and *B* shews the method of trussing girders, as is used by the greatest masters at this time.

*C* is a horizontal section of *B*.

*D* is a section of the butment, by cutting across *a b* in *A*.

*E* and *F* shews the two sides of the king-bolt, at *c* in *A*, which is made with a wedge-way upon the top, so that it may force out the trusses upon the butments.

### *To tighten the girders.*

Your trusses ought to be let close in to the sides of the girder, about an inch and a half on each side, and the head of your king-bolt ought to be greased, so that it may slide freely past the ends of the trusses; first screw your girder close sideways, then proceed to turn the nut of the king-bolt, and another person to hit the head at *c* of the king, with a mallet, which will make it start every time it is hit, and give fresh ease at every turning of the nut, so that you may camber the girder to any degree that you shall have occasion for, but generally not above an inch in twenty feet.

*Note.* The sections *D*, *E*, and *F*, are to one eighth part of the real size.

---

## PLATE XLI.

This contains the most simple construction of roofs.

FIG. *A* is calculated for a small building; at one end of the colar-beam is the Carpenters' boast, what they term a dove-tail tenent; but I think rather a rule joint, as it is worked out to a centre. This roof will do for an extent of 20 or 25 feet.

FIG. *B* is a truss for a roof, the purlines to be notched upon the principal rafters, as will be described in the following plates of ledgment roofs: this roof may be well calculated for an extent of 30 or 35 feet, the height one fourth of the span for slate coverings.

FIG. *C* is a simple construction of a roof, for the segment finish of a dome, which will answer to any of the above extents.

PLATE



## P L A T E XLII.

FIG. *A* is a roof for the purlines to be framed in, and the common rafters to come fair with the principals.

FIG. *B* is a roof calculated for a greater extent than any of the foregoing roofs, and may well extend 50 or 60 feet. Here likewise is shewn the connection of the roof in the walls.

FIG. *C* is a roof supported by two queens, instead of a king, to give room for a passage or any other conveniency in the roof.

## P L A T E XLIII.

This roof is calculated for a span of seventy or eighty feet.

You will observe in this, and the foregoing roofs, that the trusses are the same in number as the purlines which they have to support; for how absurd it is to give a roof more strength than necessary; but, on the other hand, the consequence will be dangerous if too weak.

FIG. *A* is a design of a roof for a theatre, which may extend from 80 to 90 feet.

As it happens frequently in buildings that walls run across the roof, in such cases there will be little occasion for trussing the roof; then the purlines may be trussed, which will save one or two pair of principals, which is a considerable advantage.

FIG. *B* is a roof of this kind, which shews the ends of the purlines, and *C* shews how to truss the purline.

*D*, *E*, and *F*, are the methods of scarfing timber.

P L A T E XLIV. is explained on the Plate.

## P L A T E XLV.

FIG. *A* is a curb roof, with a door in middle of the partition; the beam *a b* to run quite across the pole plate, to be tenented into the beam at *a* and *b*; the story post *a c* and *b d* likewise to be let in with a small tenent to the beam, as it should project about an inch on each side of the beam, to take the shoulder of the pole plate, which will discharge the weight from the tenent.

FIG. *B* is a roof calculated for two rooms.

FIG. *C* shews the method of framing a bridge floor.

P L A T E



Plate 42.

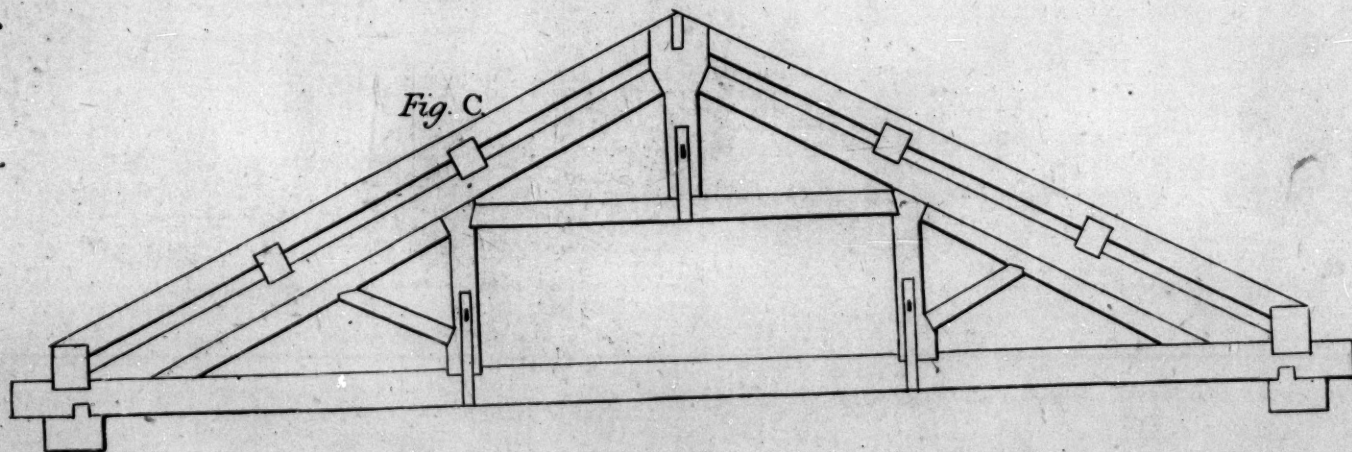
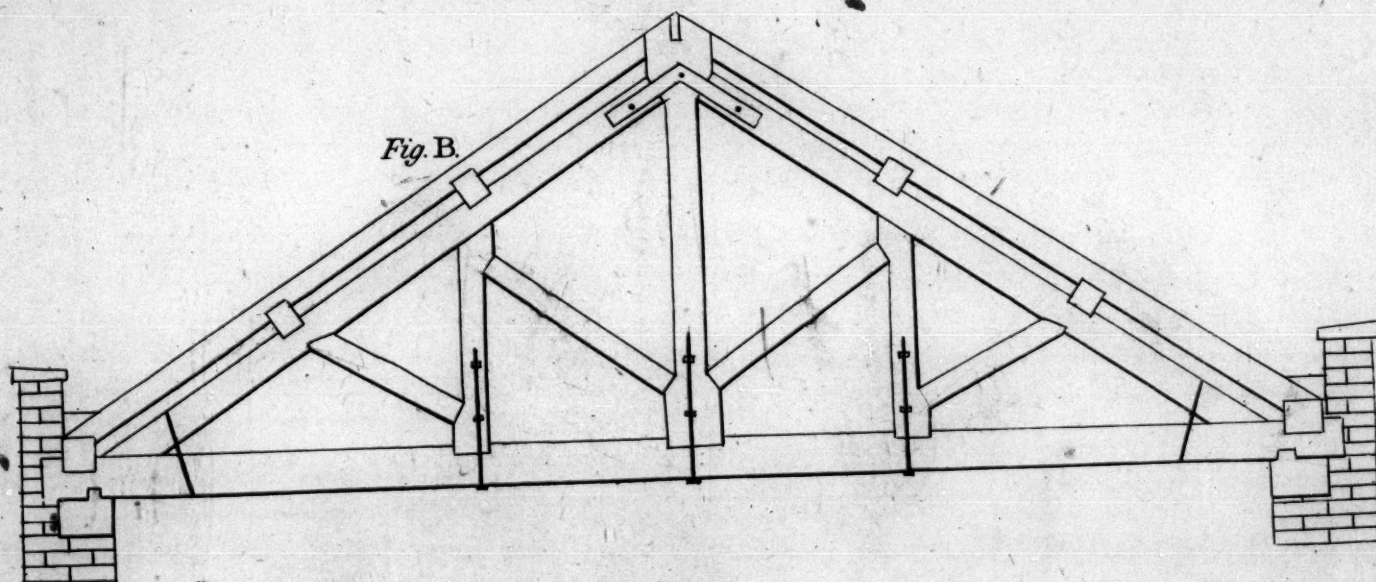
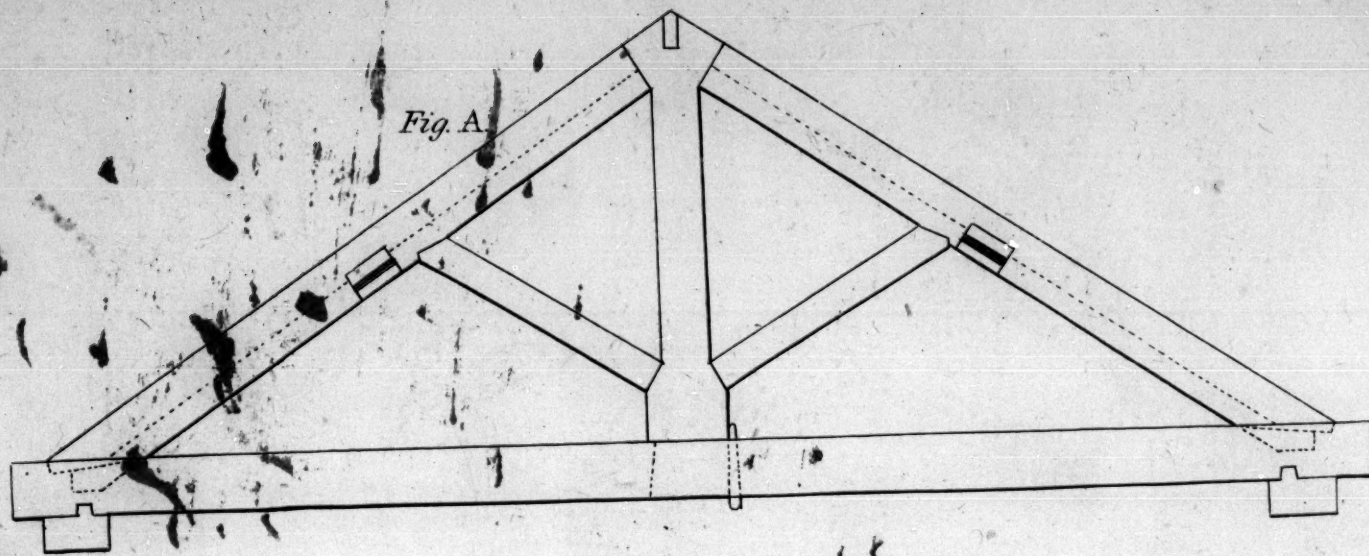
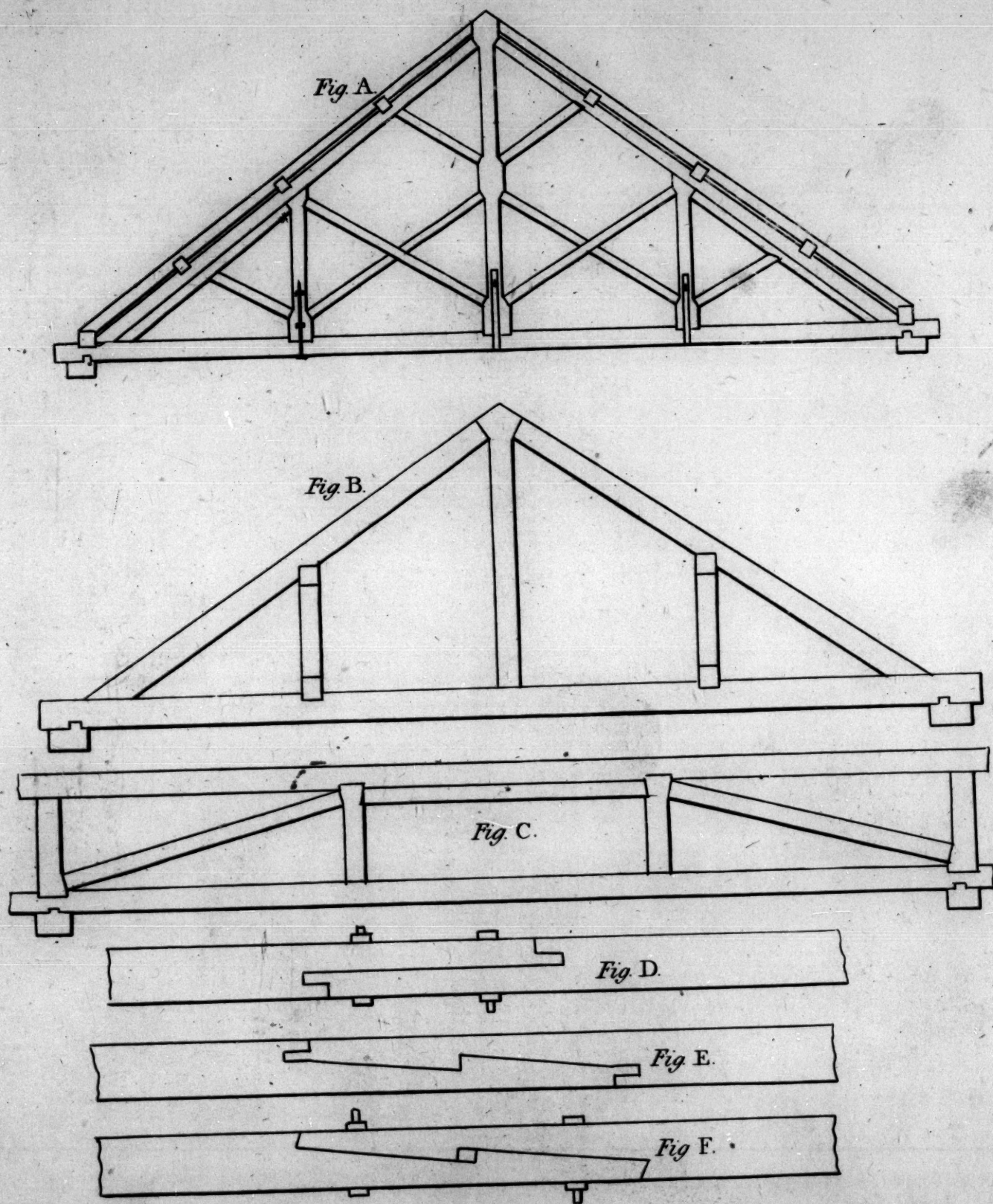








Plate 43.

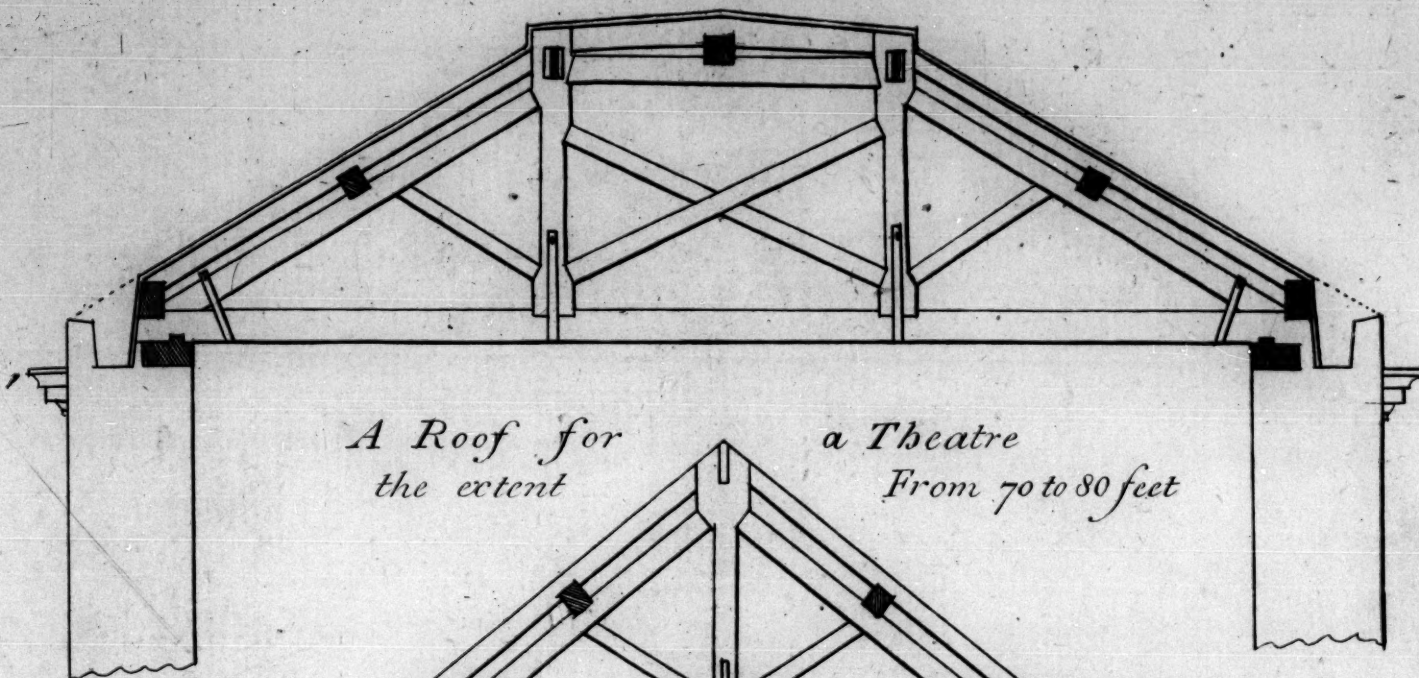




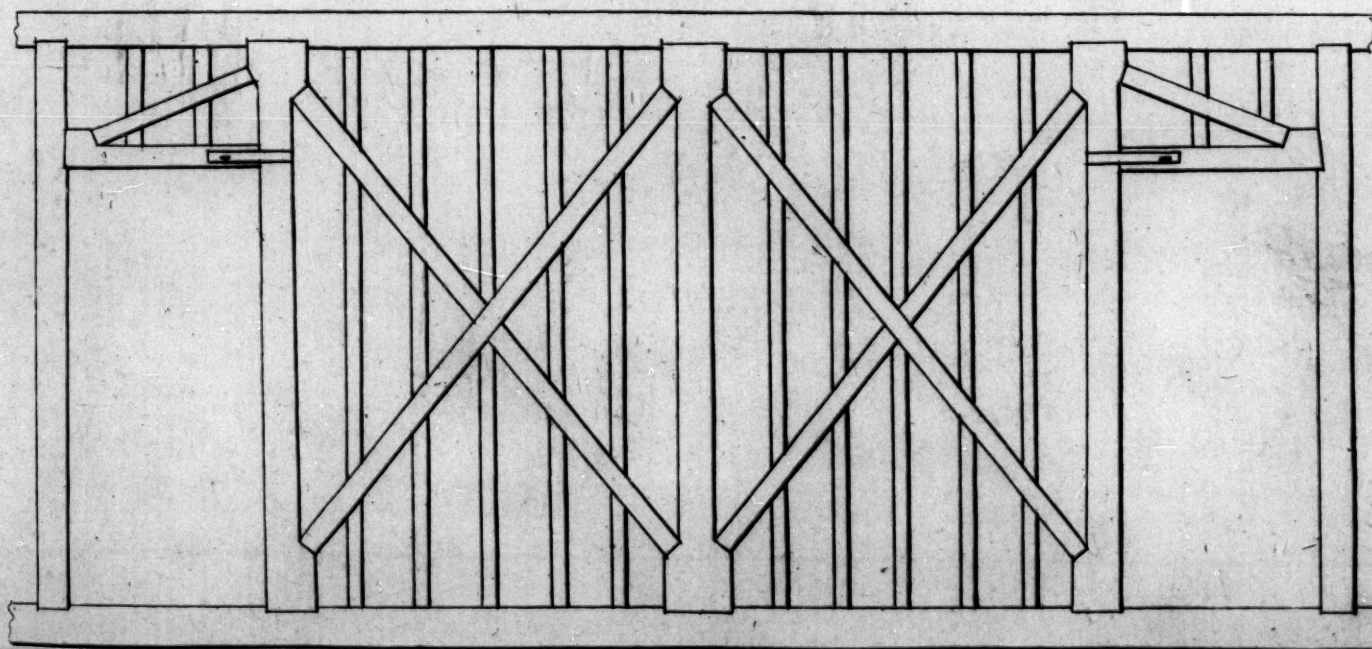




*Plate 44.*  
*A design of a roof to Finish with the parapet when covered in, the extent from 30 to 40 feet ~*



*A design for a Partition*



*Pub<sup>d</sup> as the Act directs Oct. 22. 1792. by P. Nicholson*







Platz 45.

Fig. A.

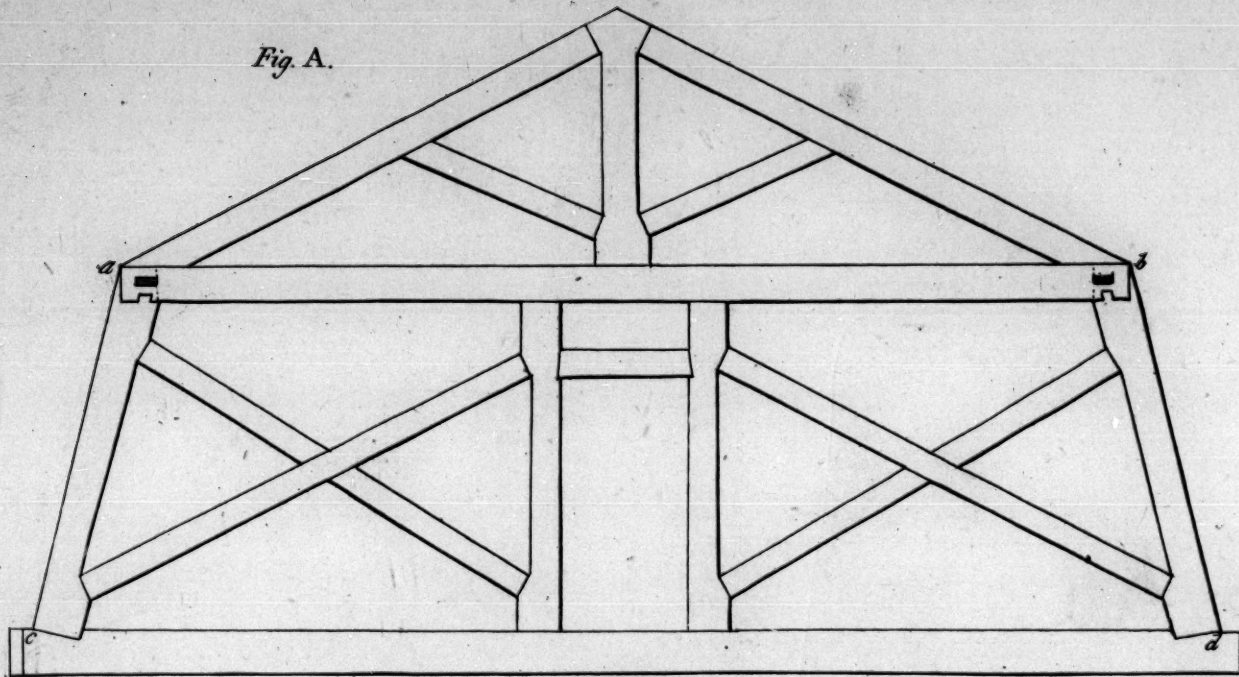


Fig. B.

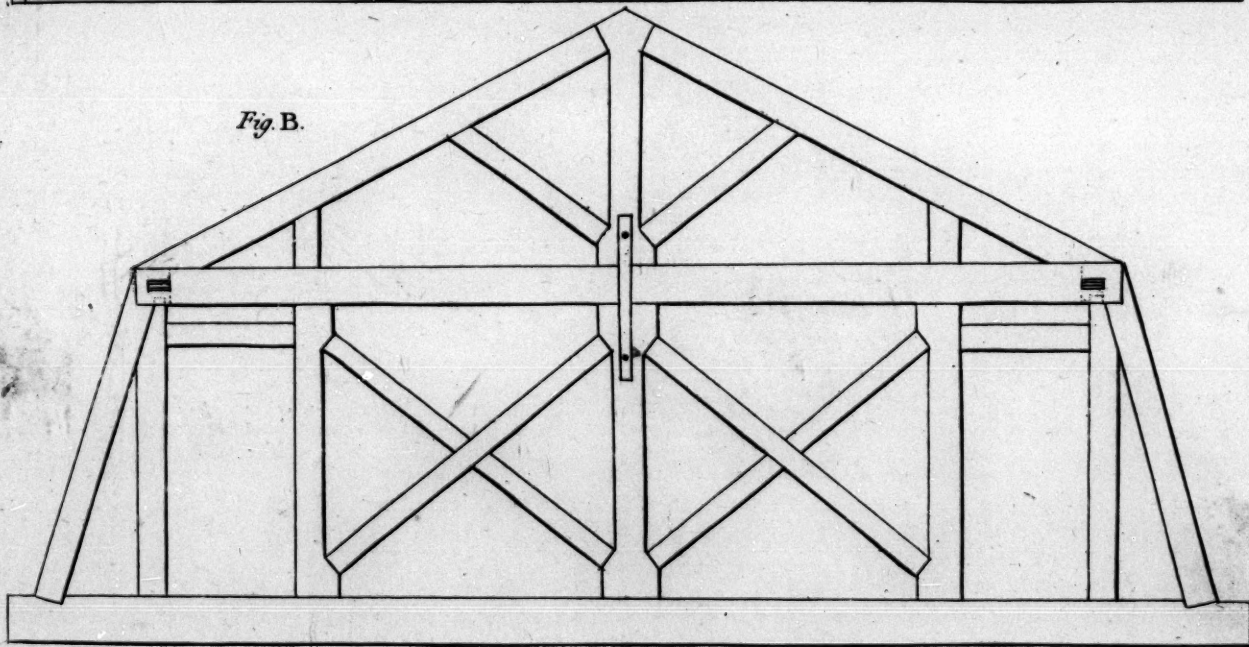
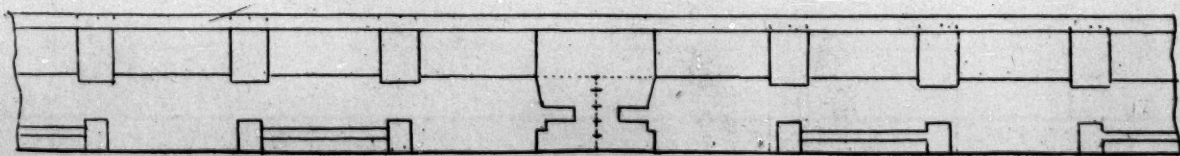


Fig. C.



Pub<sup>d</sup> as the Act directs June 9. 1792 by T. Nicholson.



*John*









Plate 46

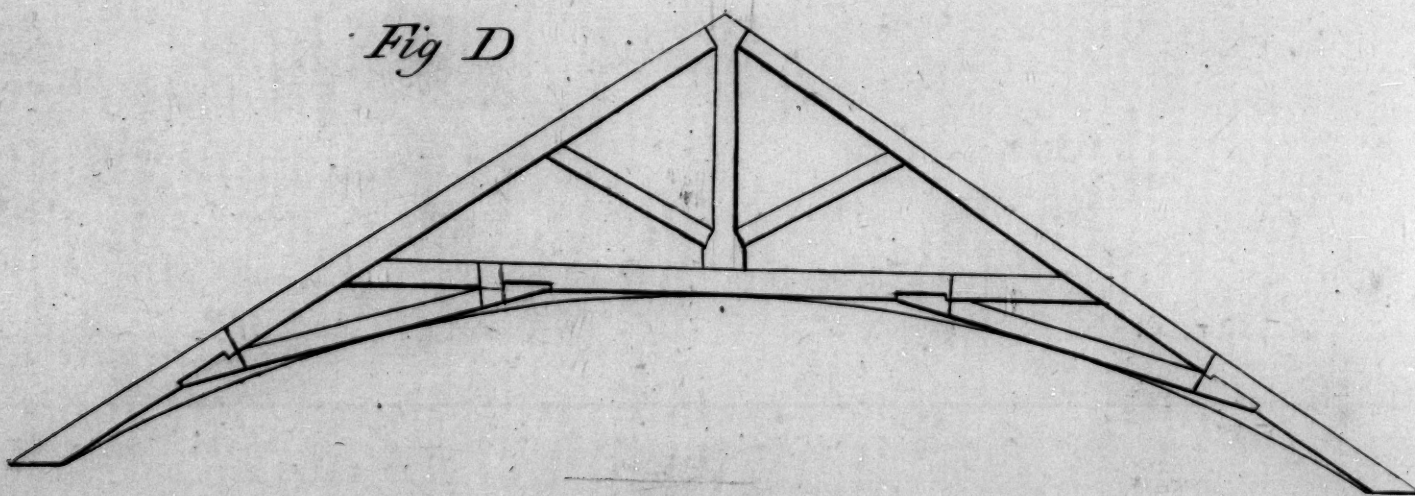
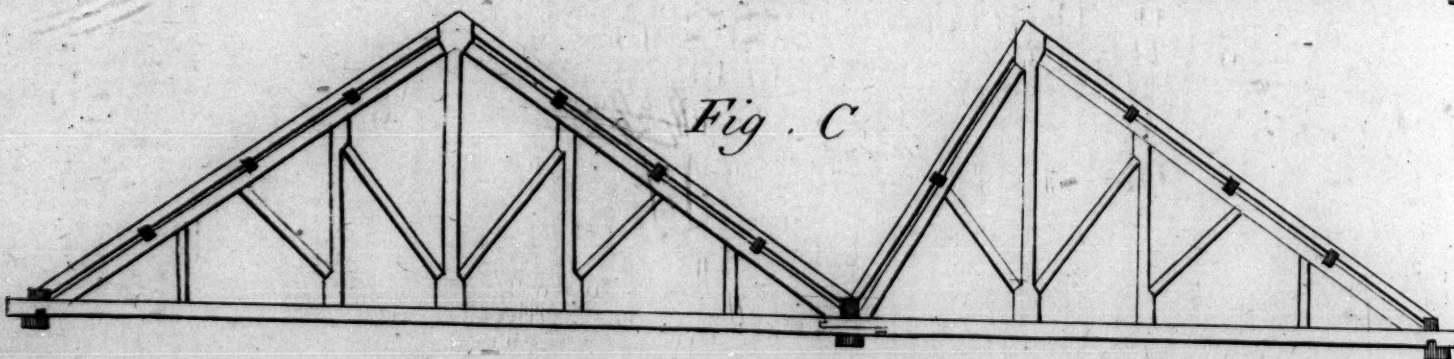
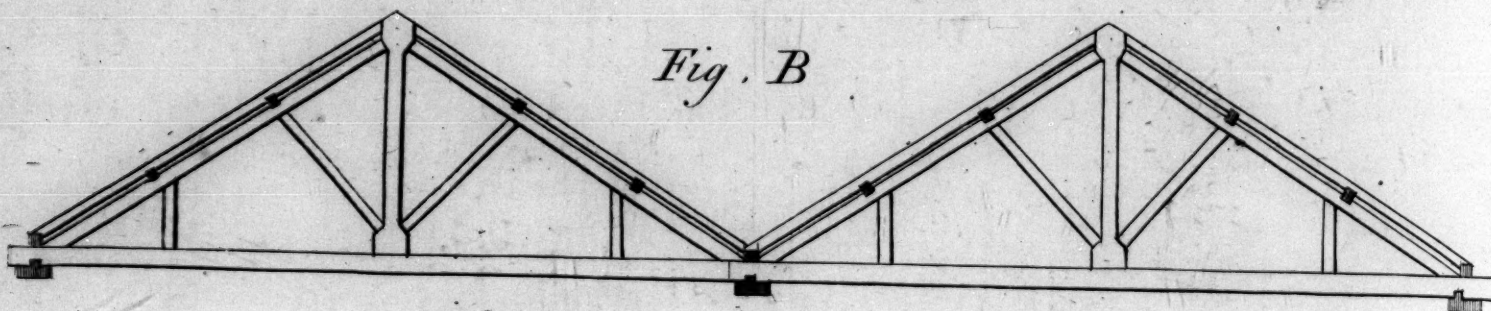
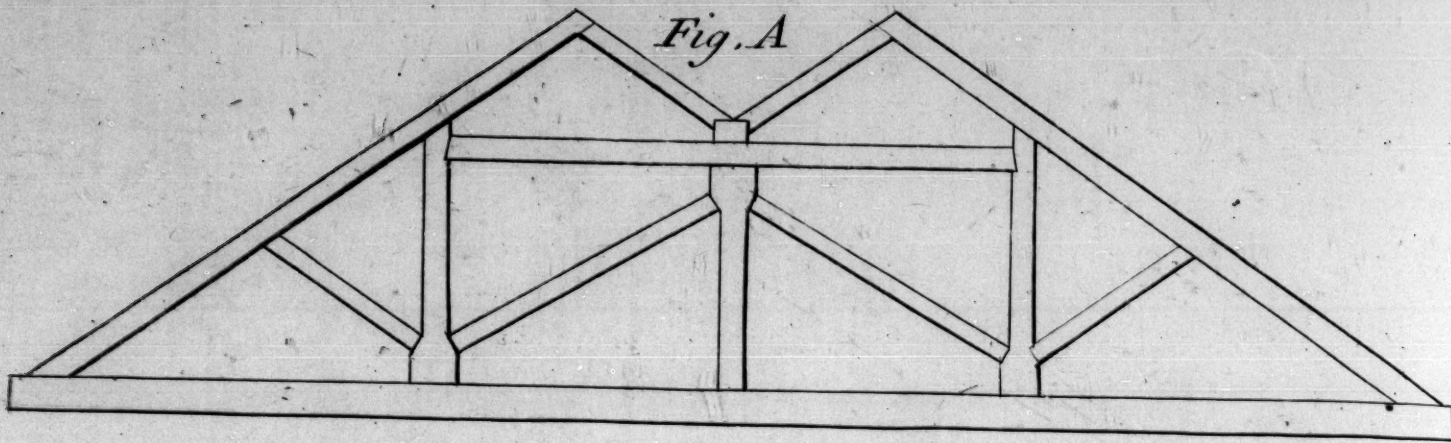








Plate 47

Fig A

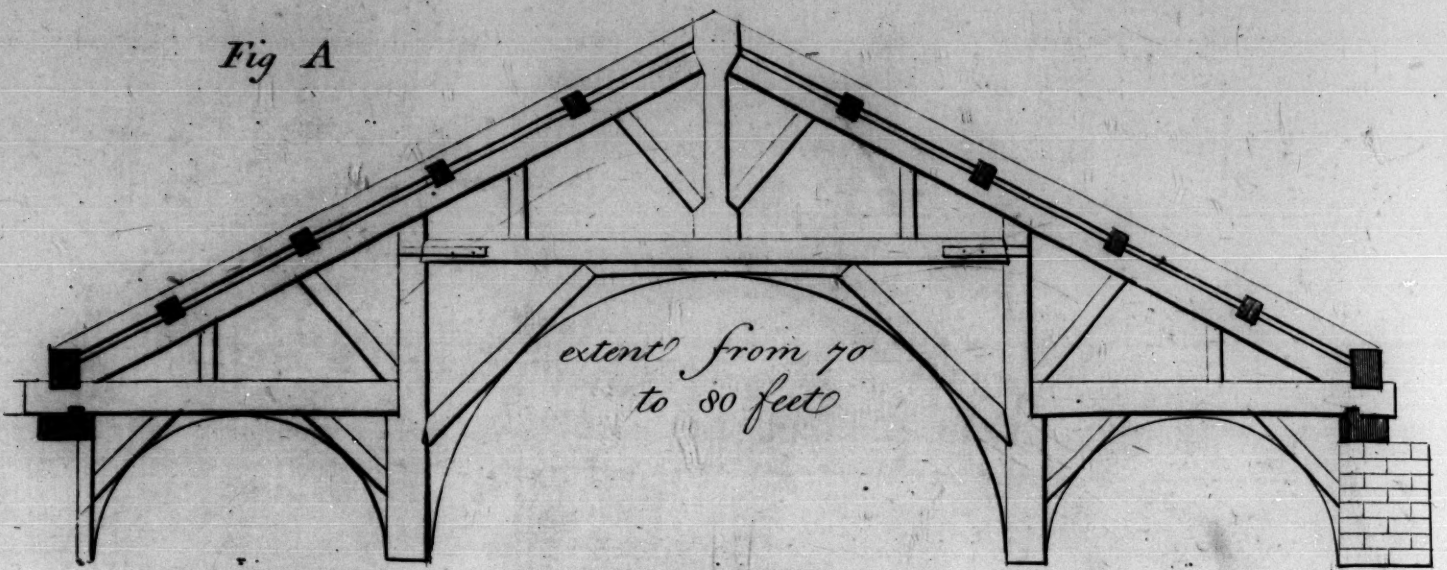


Fig B

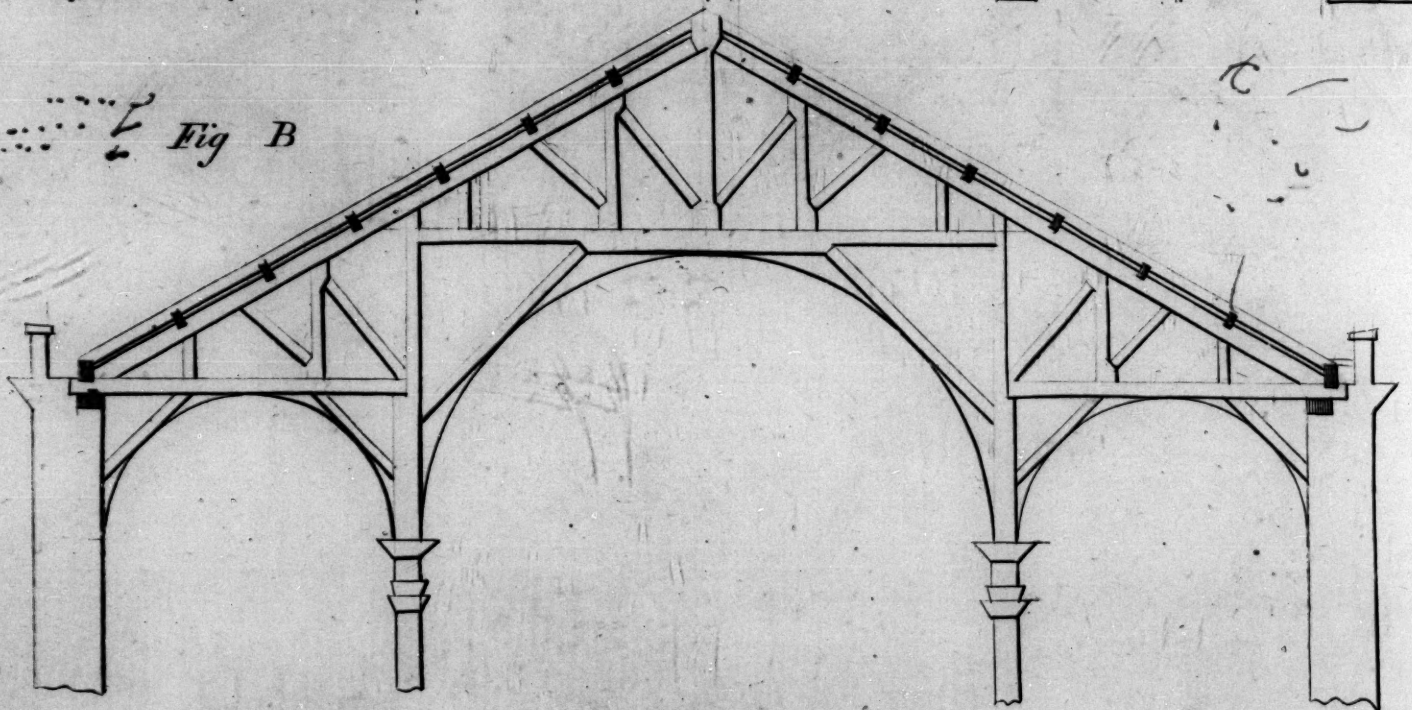


Fig C

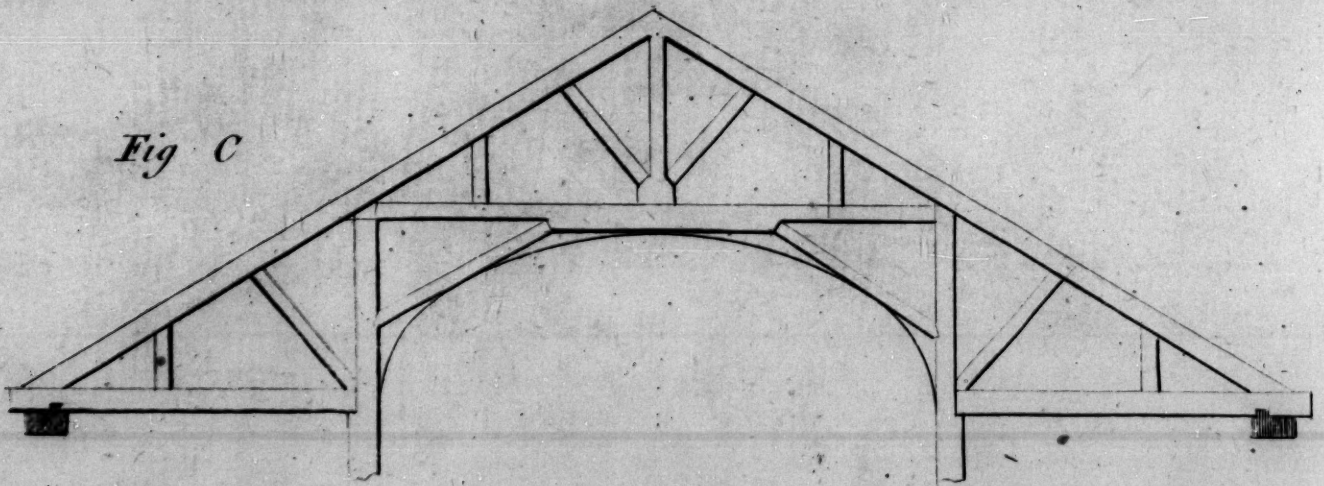
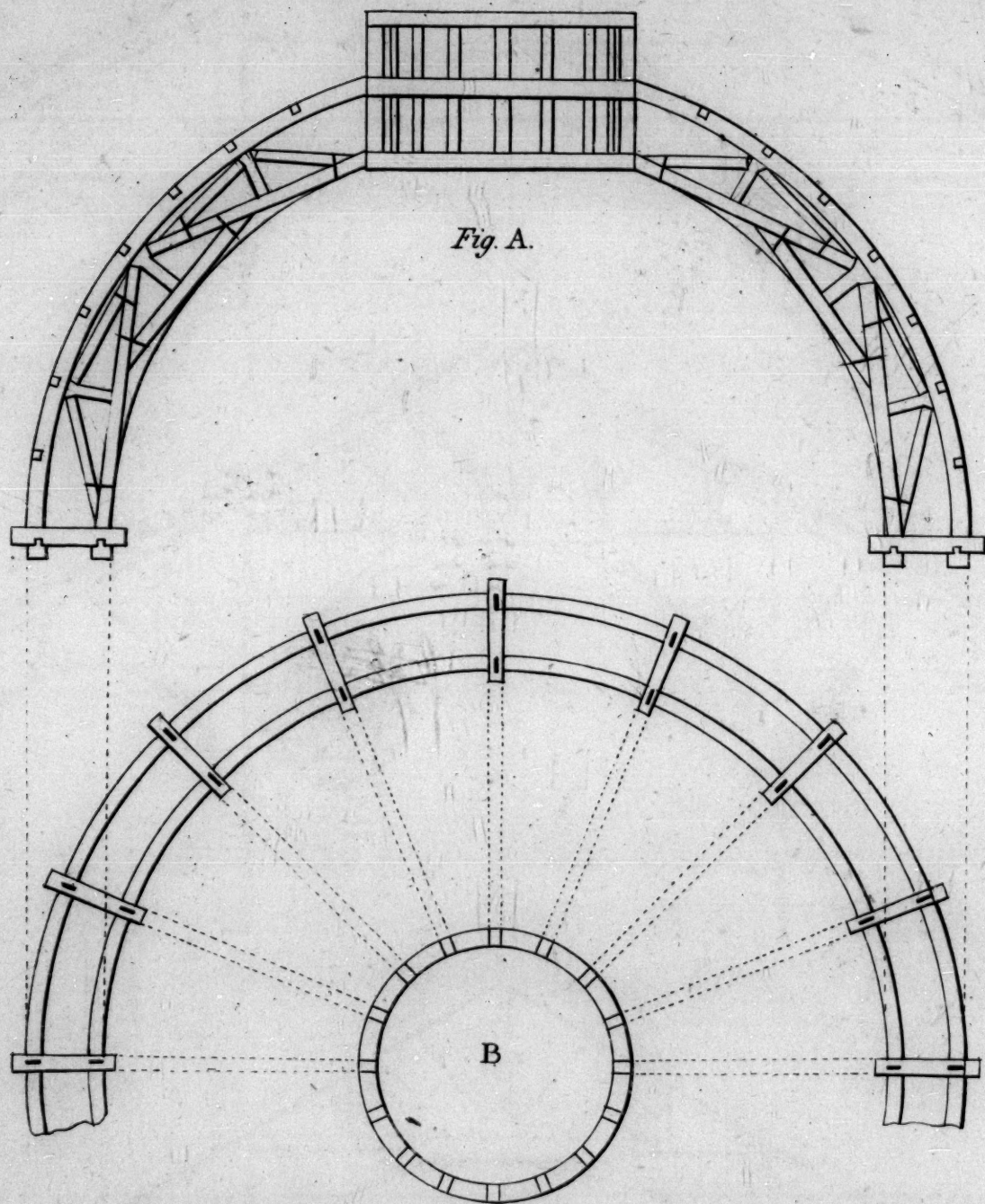








Plate 48.



Pub<sup>d</sup> as the Act directs June 9. 1792 by P. Nicholson.





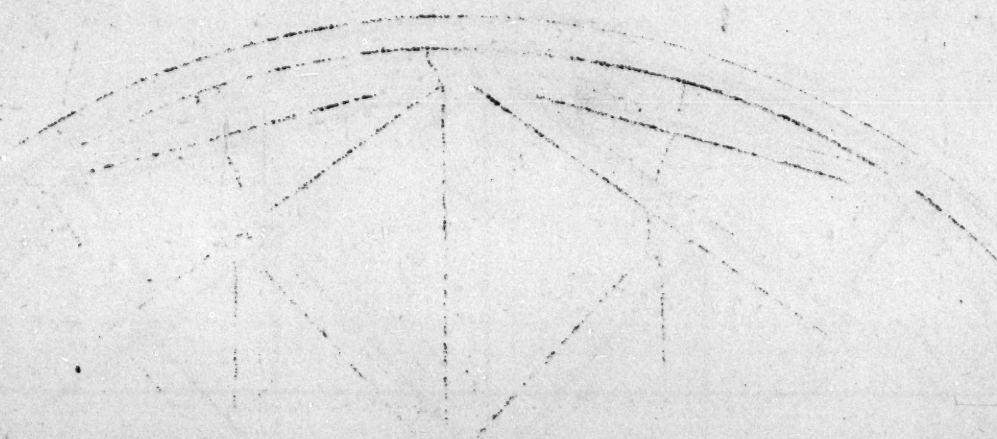
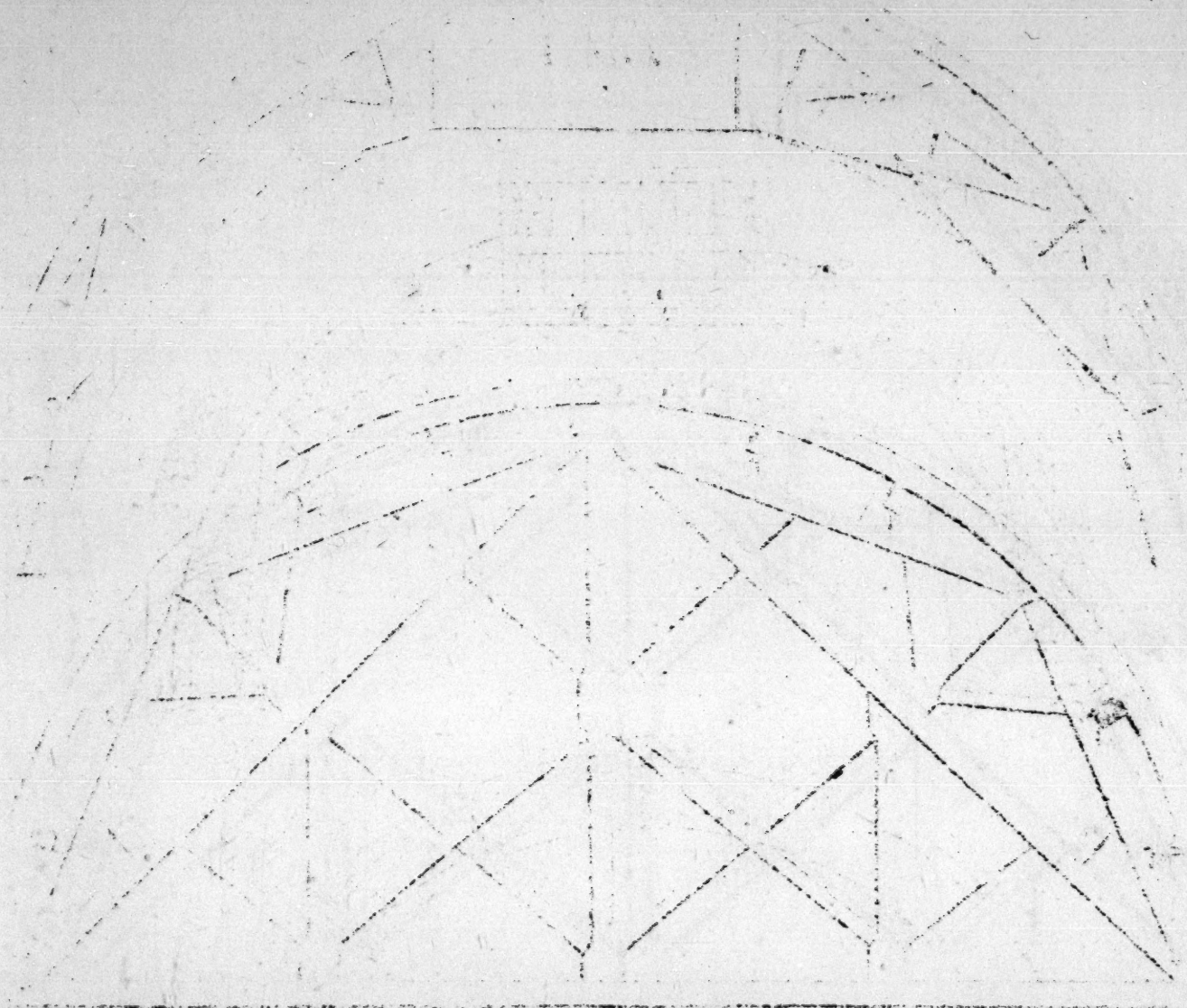




Plate 49

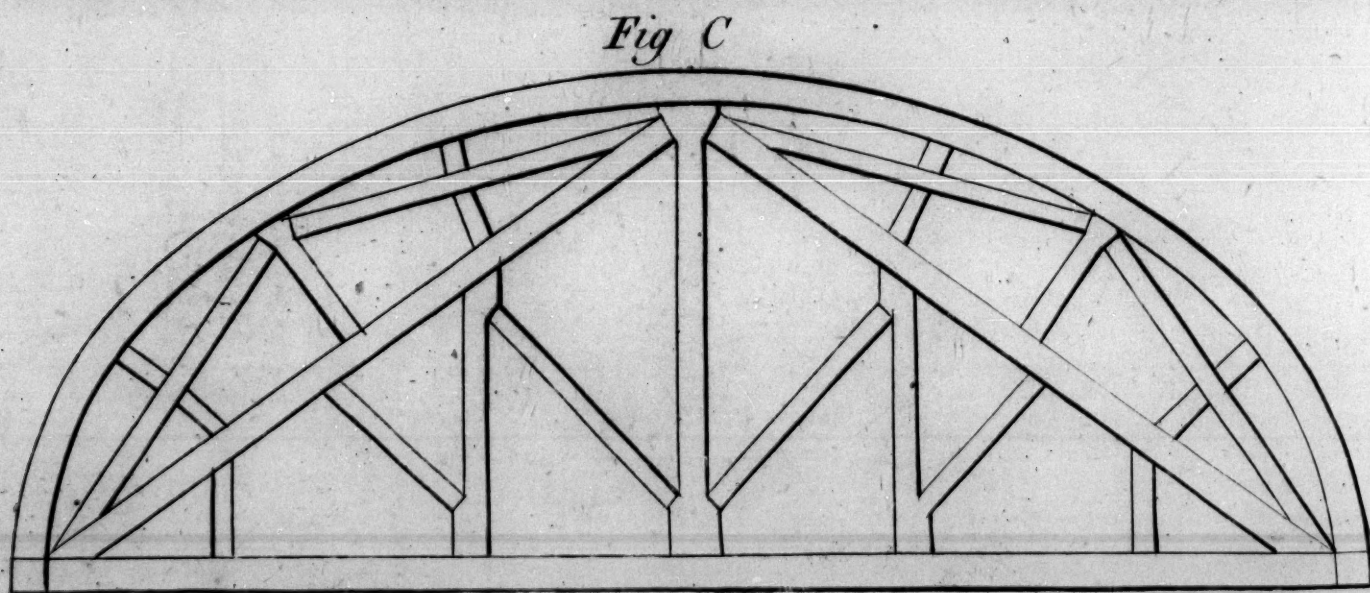
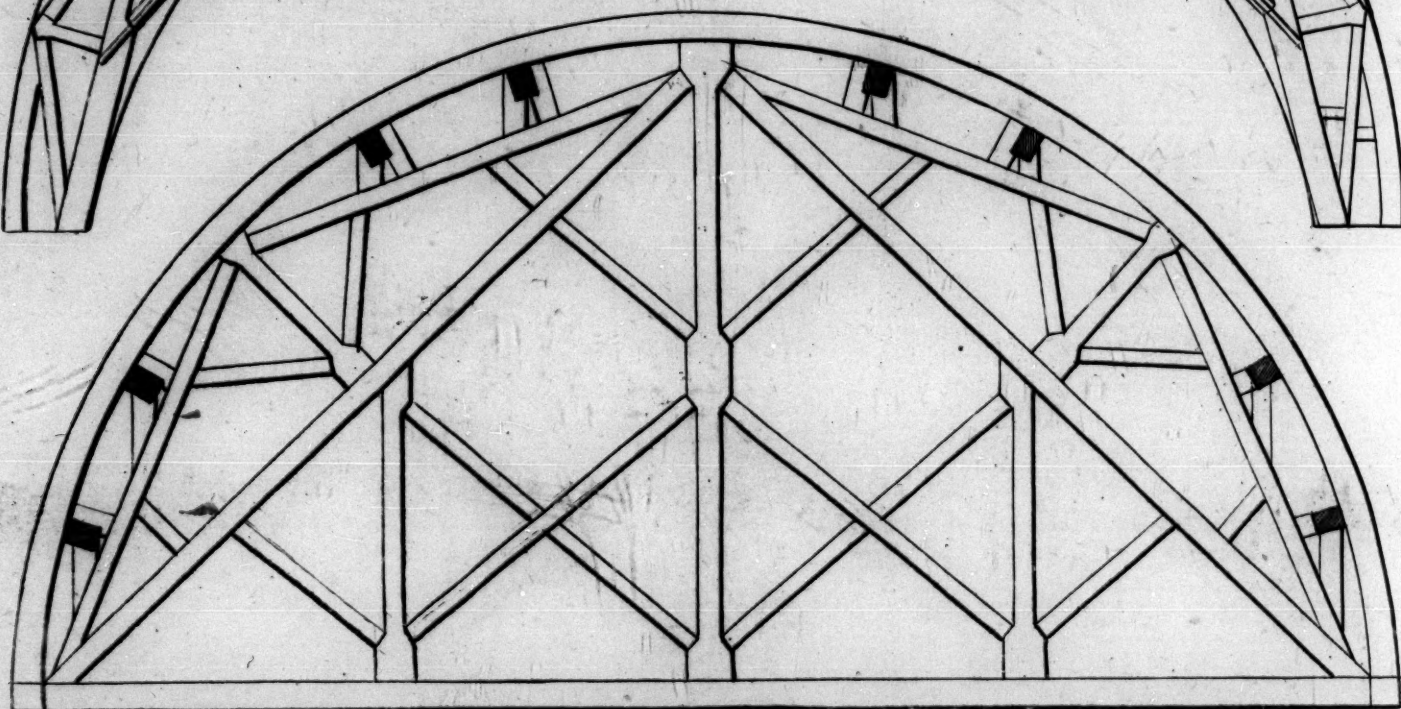
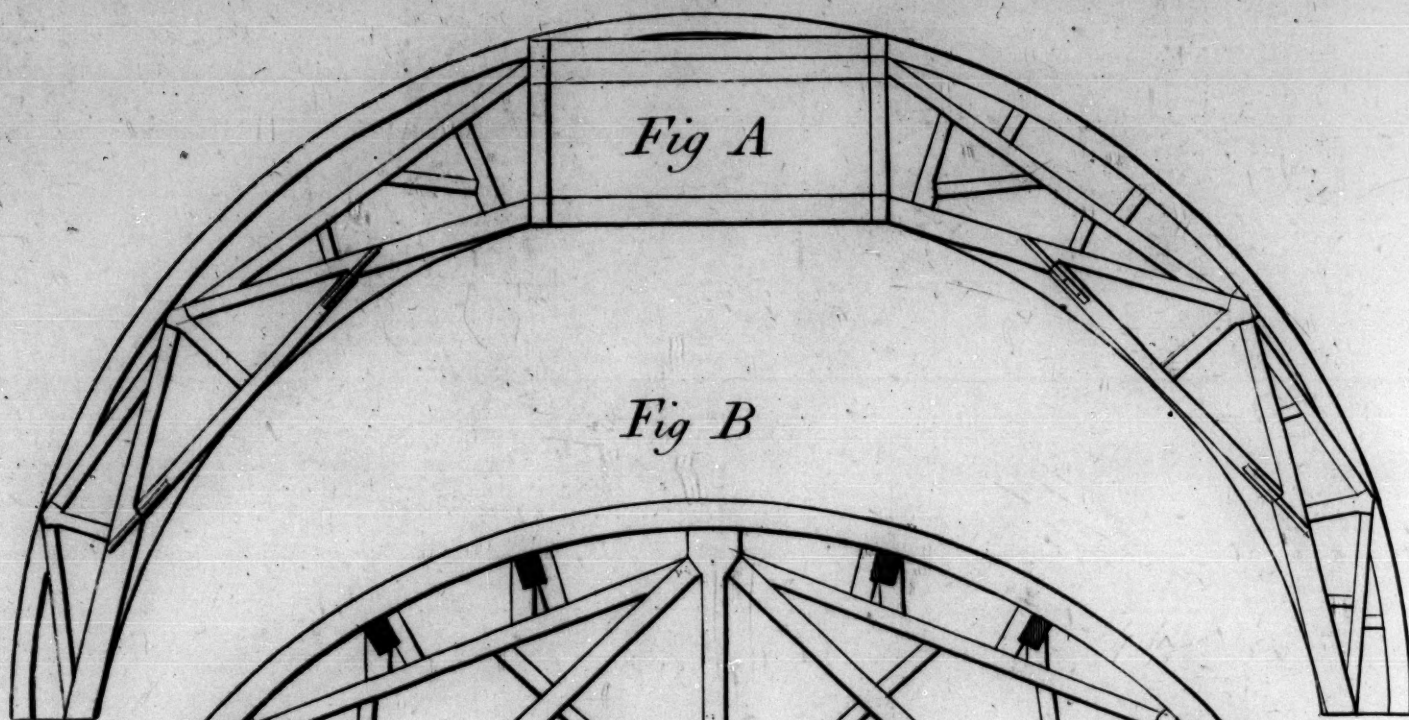
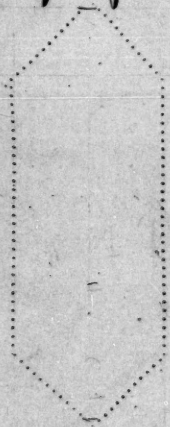
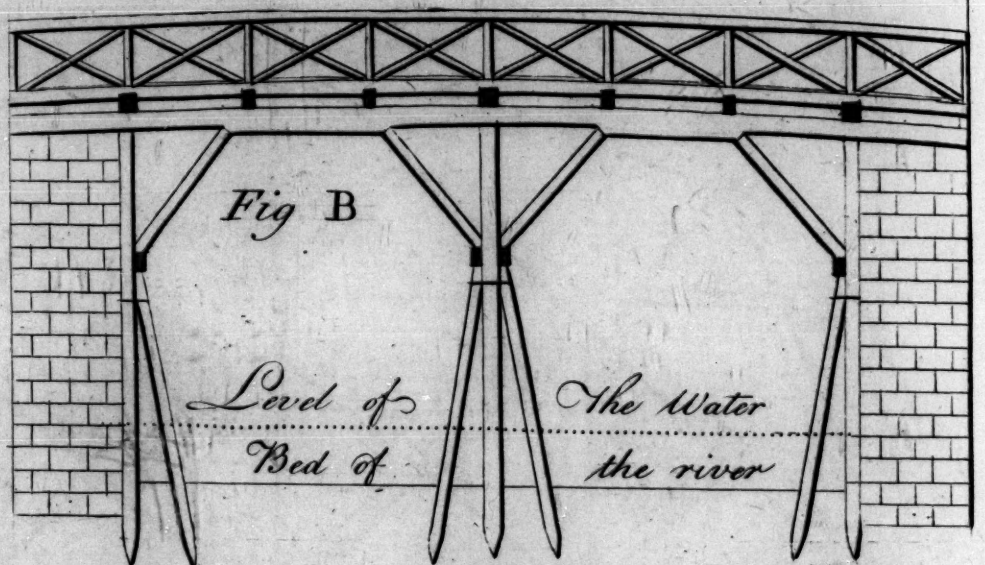
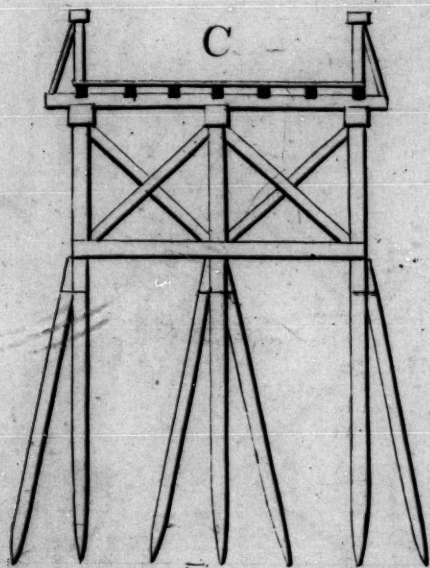
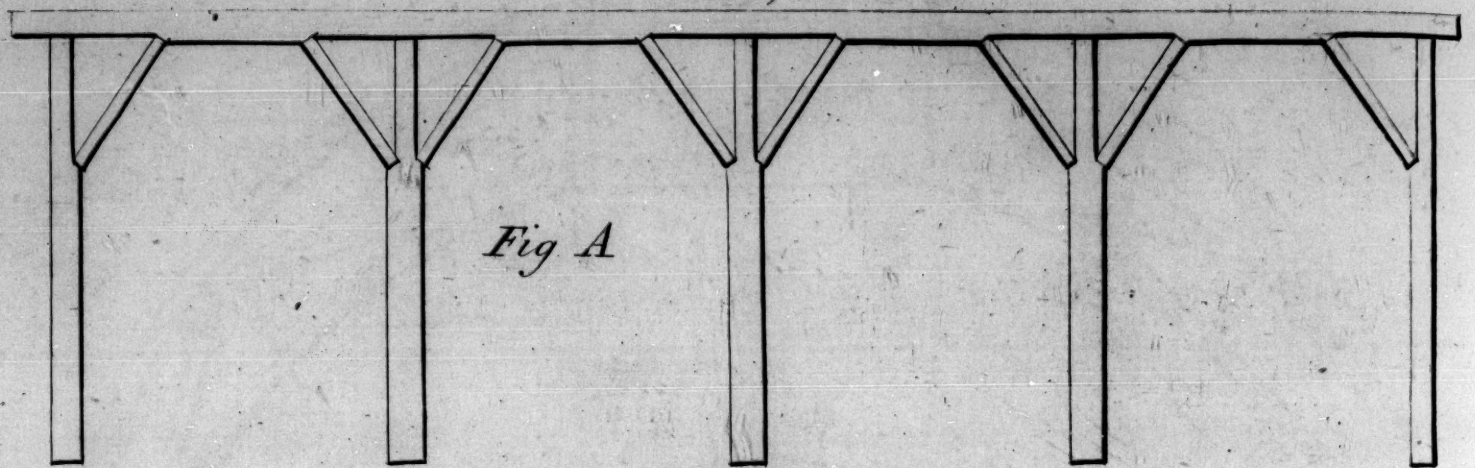




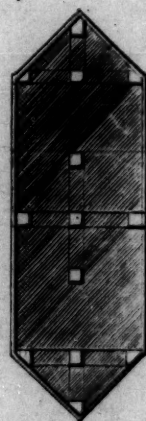




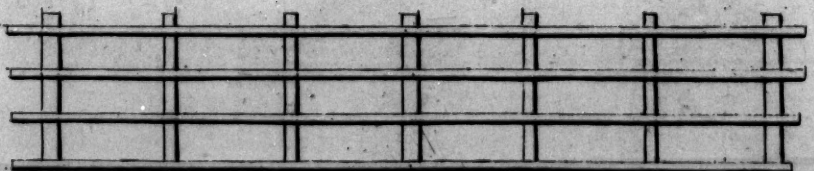
Plate 50



D



E



These  
Figures  
are  
from  
the  
original  
drawing



## P L A T E XLVI.

FIG. *A* is a design of an M roof, which is useful in some cases where the span is great, and no wall between, and the roof is required not to appear of a great height; but this seldom happens in practice, for if there is any wall between the external walls, the roofs are in general made double, as are shewn at figures *C*, *B*, and *C*.

## P L A T E XLVII.

FIG. *A* is a design for a church roof, the extent marked on the plate.

FIG. *B* is a design of the same kind, but may be applied to an extent much greater. These two roofs, when finished, will be the same in every respect as the Welch groin described in plate 23; as the manner there shewn of fixing the ribs will not be different in this, I refer the reader to the description of that plate.

FIG. *C* is another design for a church roof, where the ceiling over the galleries is to finish level.

## P L A T E XLVIII.

FIG. *A* is a design for a domical roof; *B* shews the manner of framing the curb for it to stand upon, the section of the curb being also shewn upon the bottom of fig. *A*.

## P L A T E XLIX.

FIG. *A* is another design for a domical roof; the bottom of it is made into a very narrow compass in order to gain room within the dome.

FIGURES *B* and *C* are designs for circular and elliptical trusses for bridges, &c. These trusses may also be applied to roofs where there is no cavity wanting within.

## P L A T E L.

FIG. *A* is a design for a story post and breast-summers.

FIG. *B* is a design for a bridge. *C* is a section across. *D* is part of the plan, which also shews the manner of fixing the piles. *E* shews half the plan of the bridgings.



## PART II. Of the Theory and Practice of Joinery.

### PRINCIPLES of HAND-RAILS for STAIR-CASES.

I AM now going to enter upon a subject, which wants more particularly to be laid down by new methods, than any of the others which I have before touched upon; as the methods laid down by all authors on the subject are grounded upon erroneous principles, without any proper foundation, and not considering it truly according to its nature. For it is evident, that if a cylinder is any how cut, but not parallel to the base, that section will be an ellipsis; and if the cylinder is perpendicular, the section will also be perpendicular to the base, or plumb from every point in it to every corresponding point in the base or plan: and likewise, if you suppose any other section to be cut under the former, and parallel to it, then the ellipsis under will be the same as that above; and therefore I say, if a mould is made to this ellipsis, let it be drawn upon the upper side of a plain piece of wood, of a parallel thickness; then if the bevel where the ellipsis cuts the cylinder be applied to either of the extremes upon the edge, and the same mould being applied from the rake of that line to the under side, then let the plank be cut out between the rake of the upper and under lines; and if this is taken into consideration, it will appear that hand-rails are the sections of cylinders, and consequently the rules for drawing them will be the same as those for finding the section of a cylinder, which has been explained in the Geometry, see plate 9 and its explanation; or if they are made in several different pieces, they will still be some portion of a cylinder, which are all explained in the plate before mentioned.

### P L A T E L I.

#### *To draw the form of a hand-rail.*

In *fig. A* make an equilateral triangle *v w t* upon its width, and divide it into five equal parts, and from one part on each side draw *z s* and *y w*, then *t g* and *m* are the centres, *l m* being made equal to *l g*; the centres are found the same for the upper side.

#### *The form of the rail being given, to draw the mitre cap.*

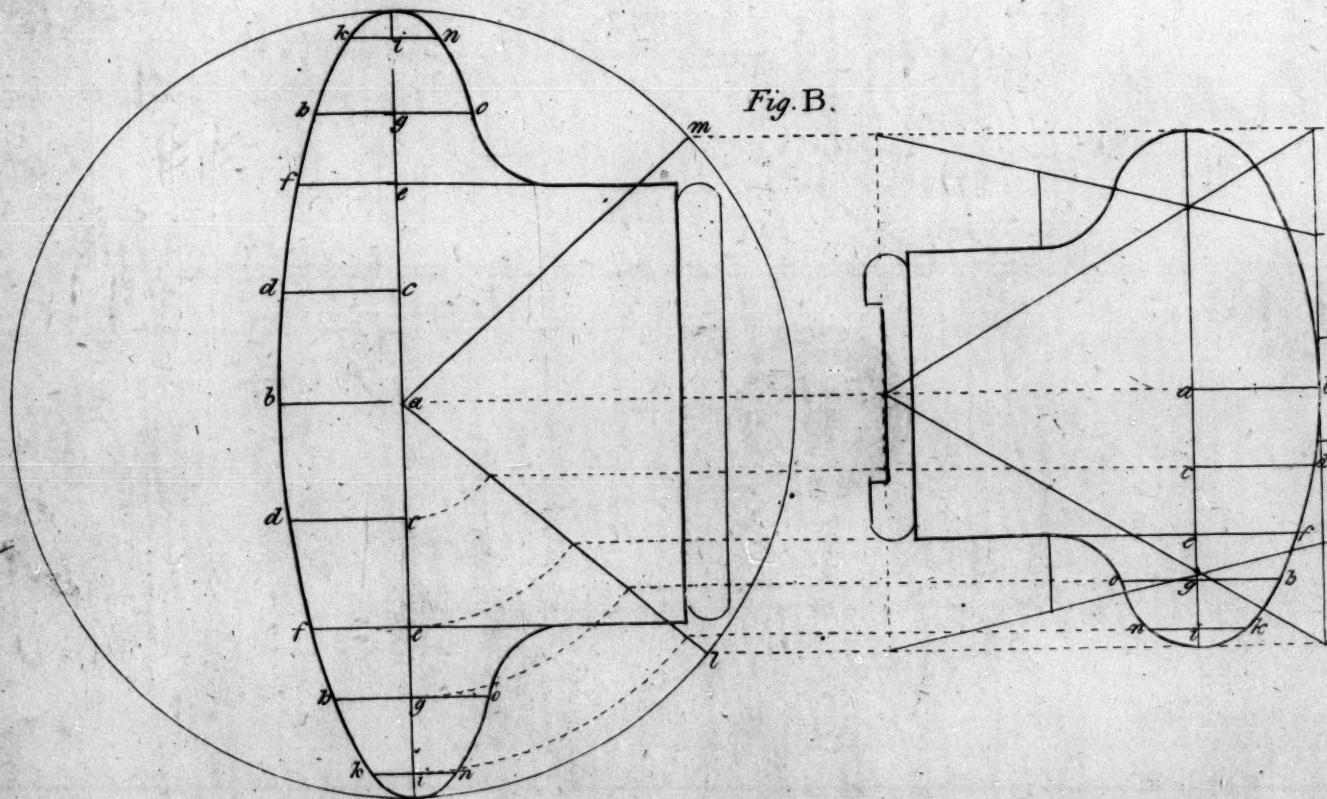
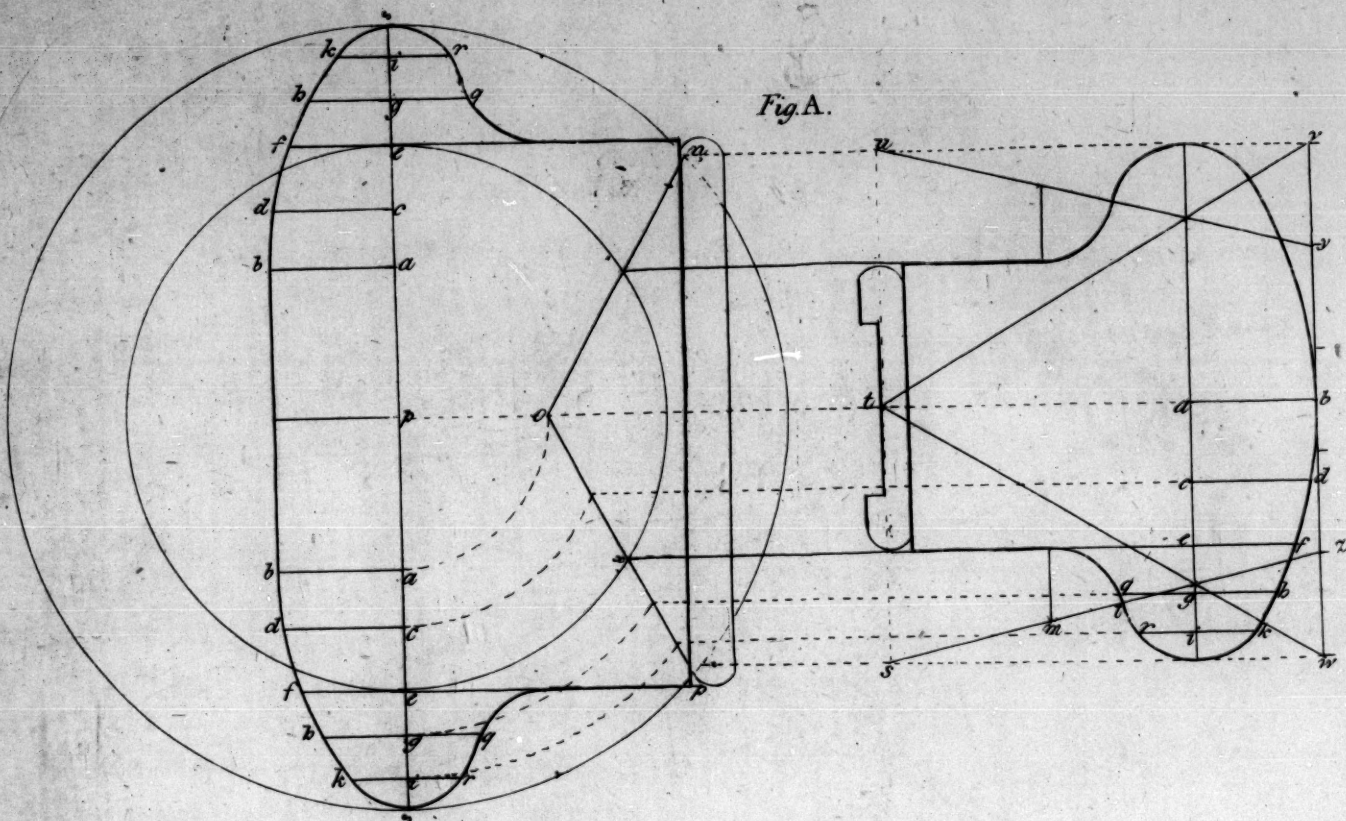
Let the projection of the cap be three inches and a half, and make the distance of the inside circle from the outside circle the projection of the nose on each side of the rail, and draw the mitre *n o* and *p o*; then continue parallel lines down to the mitre *p o*, put the foot of your compass in the centre of the cap, and circle the parallel lines round to *a c e g* and *i*, and draw the ordinates *a b, c d, e f, &c.* and then prick the cap to the rail according to the letters.

#### *How to draw the form of the cap for the mitre to come to the centre.*

It is only drawing the parallel lines from the rail to the mitre wherever it is, and circling them round to the ordinates, and so pricked from the rail, and the thing is done.



Plate 51.



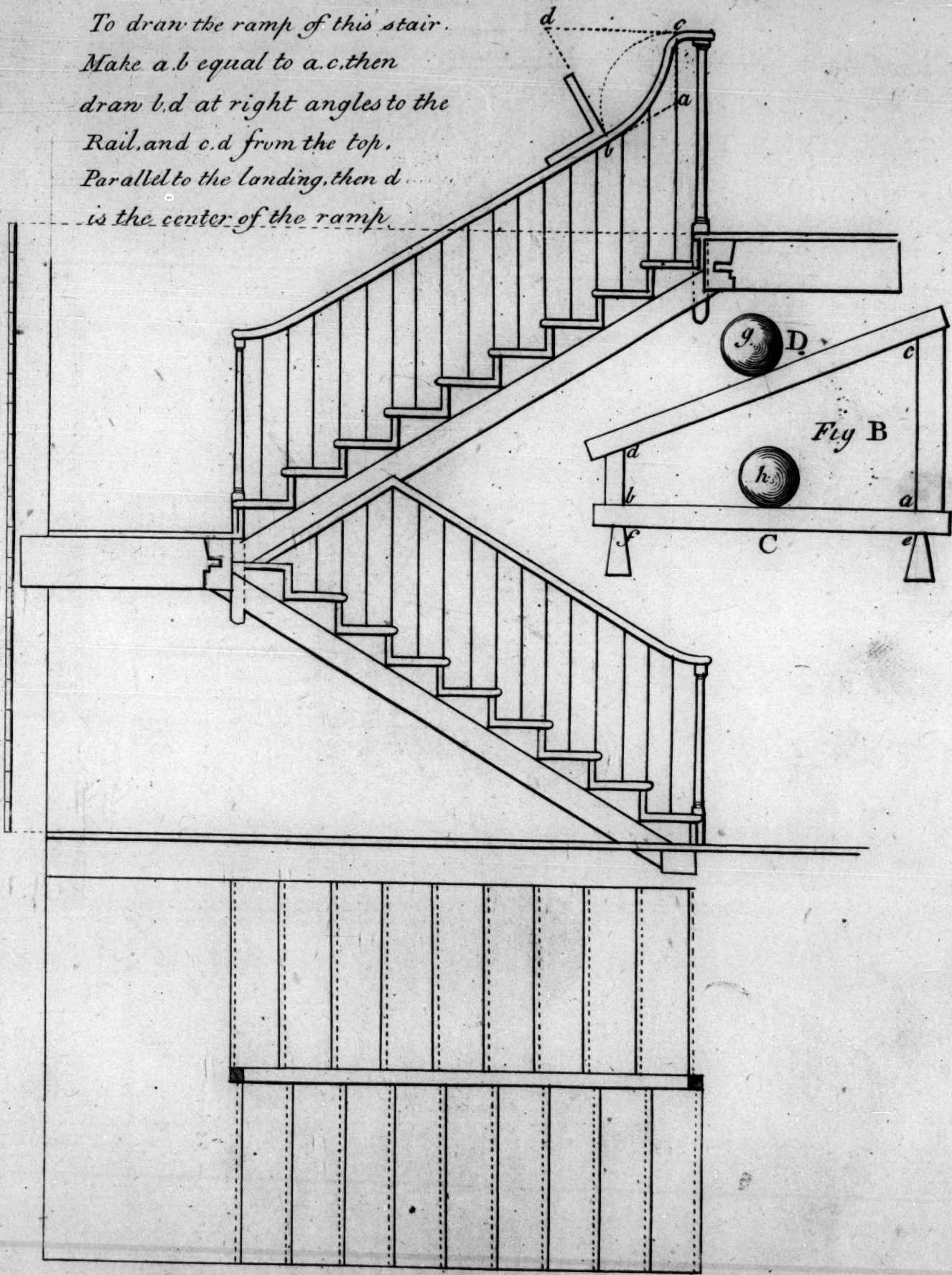






*Plate 52.*

To draw the ramp of this stair.  
Make  $a.b$  equal to  $a.c$ . then  
draw  $b.d$  at right angles to the  
Rail, and  $c.d$  from the top,  
Parallel to the landing, then  $d$   
is the center of the ramp

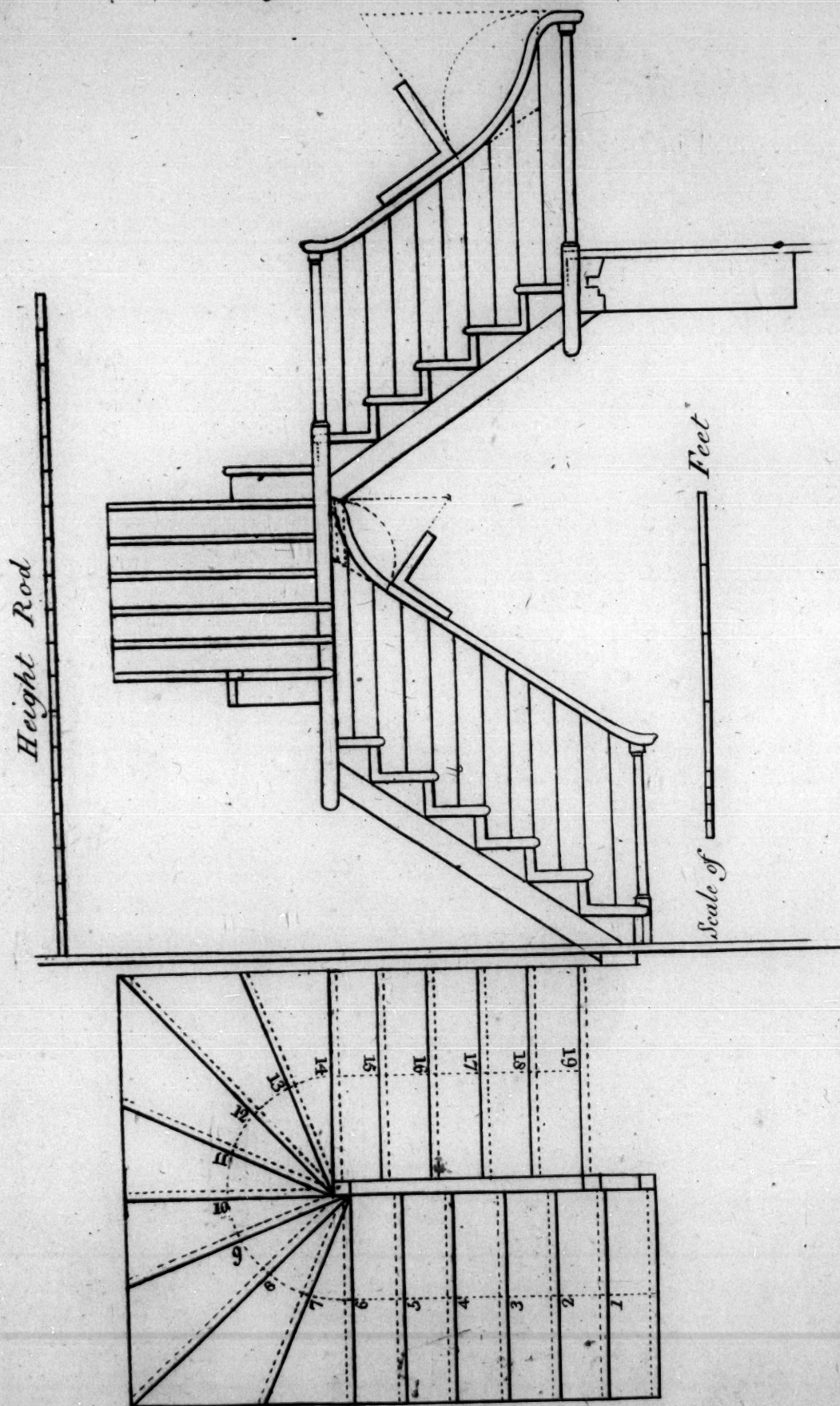








*Plate 53.*  
*A dogleg Stair Case with Winders*



*Pub<sup>d</sup> as the Act directs Nov. 8 by P. Nicholson*



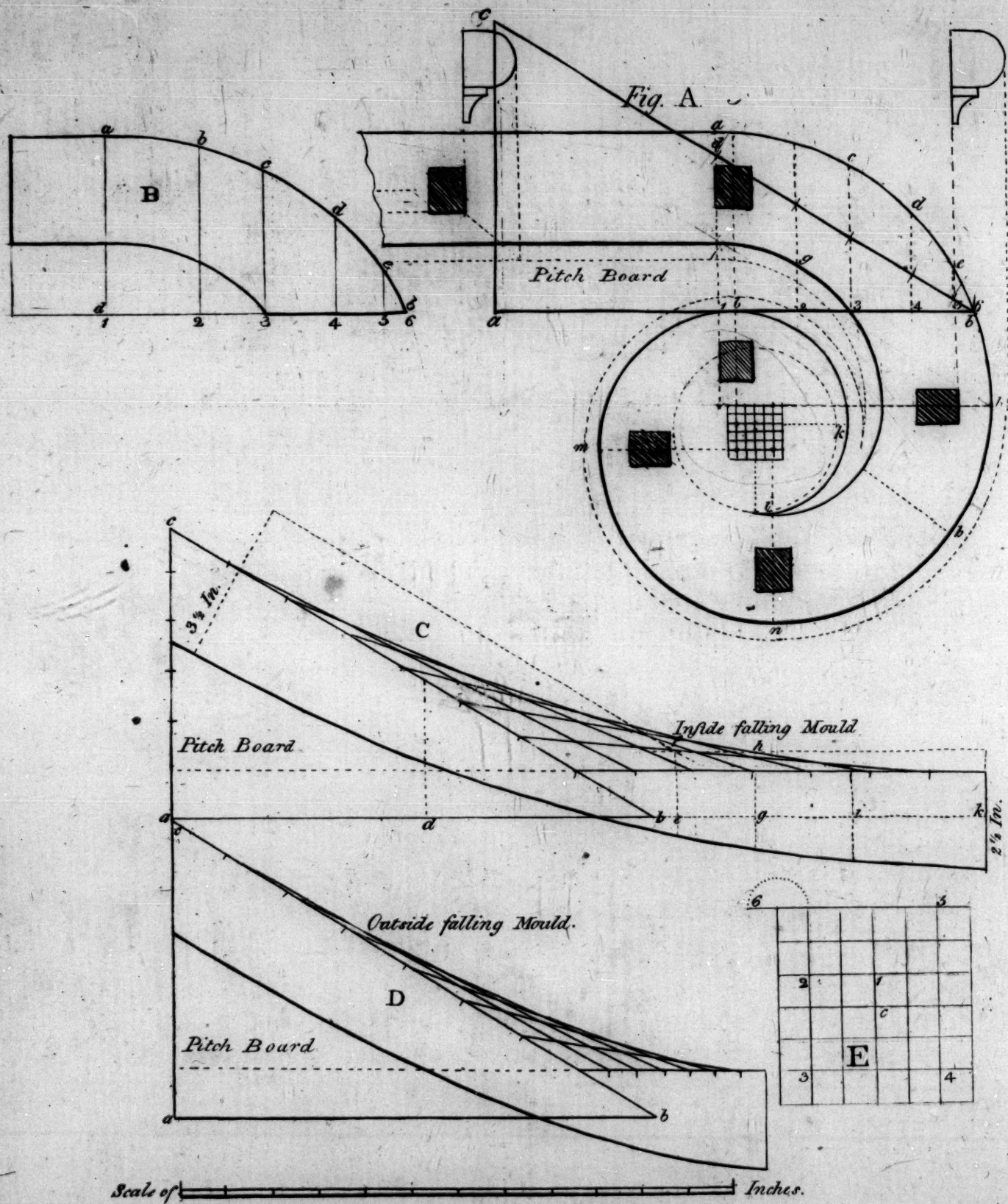








Plate 54.





## P L A T E L I V.

*To draw the scroll of a hand-rail.*

In *fig. A* make a circle three inches and a half diameter, divide the diameter into three equal parts, and make a square in the centre of the eye to one of those parts, and divide each side of the square into six equal parts; this square is shewn in *E*, at the bottom, in full size for practice, and laid in the same position as the little square above, so that the centres may be more readily found, which are all marked in a regular position; the centre at 1 draws from *i* round to *k*, the centre at 2 draws from *k* to *l*, and the centre at 3 draws from *l* to *m*, &c. which will complete the outside revolution at *a*, with the centre *c*; then set the thickness of the rail from *a* to *f*, and go the reverse way to draw the inside; then the scroll will be completed.

*To draw the curtail step.*

Set the ballisters in their proper places on each quarter of the scroll in *fig. A*; the first ballister shews the return of the nosing round the step, the second ballister is placed at the beginning of the twist, and the third ballister a quarter distant, and straight with the front of the last riser: then set the projection of your nosing without, and draw it all round equal distant from the scroll, which will give the form of the curtail.

*To draw the face mould for squaring the twist part of the scroll.*

You will observe here, that the joint is made at 3, 6, just to clear the side of the scroll; draw ordinates across the scroll at discretion, to cut the line *db*, *abc* being the pitch-board; take notice that lines be drawn from 3 and 6 to meet *db*, so that you may have the said points exact at 3 and 6 in your face mould, then take the line *db*, and mark the places of the ordinates upon a rod, and transfer the divisions to *db* in *B*, then trace *B*, from *fig. A*, according to the marks.

*To find the falling mould C.*

In *C*, *abc* is the pitch-board; the height is divided into six parts, to give the level of the scroll, the distance *ad*, is from the face of the riser to the beginning of the twist; and the distance from *d* to *k* in *C*, is the stretch out from *a*, the beginning of the twist round to *b* in *fig. A*; each being any point taken at discretion, more than the first quarter; divide the level of the scroll, and the rake of the pitch-board, into a like number of parts, and complete the top edge of the mould by intersecting lines, and the under edge parallel to it to the depth of the rail.

*How to find the parallel thickness of stuff for the twist and scroll.*

Take the compass round *abcde*, to 6, in *fig. A*, and stretch it out upon the base of the pitch-board from *d* to *g*; draw *gb* perpendicular to intersect with the top of the mould; then draw the dotted line *bf*, parallel to the level of the scroll both ways; then take the distance 6 1, in *fig. A*, that is, the length of the plan, for the twist part, and set it from *d* to *e* in *C*, and draw *ef* perpendicular, to cut the parallel *fb*; then draw a dotted line through *f*, parallel to *cb*, the longest side of the pitch-board, which gives the thickness of stuff for the twist, about three inches and a half; and the parallel line from *f* to the base, shews the thickness of the scroll.

*Note.* The falling mould *D*, for the outside, is found in the same manner as the other falling mould *C*.

*Jacob*



## P L A T E LV.

As the method of getting a scroll out of a solid piece of wood, having the grain of the wood to run in the same direction with the rail, is far preferable to any of the other methods, with joints in them, being much stronger than any other scroll with one or two joints, and much more beautiful when executed, as no joint can be seen, and consequently no difference in the grain of the wood at the same place. I shall here give you a specimen, the method for describing a scroll being already given in the last plate; and likewise the falling mould.

*How to find the raking or face mould.*

Place your pitch-board,  $a b c$ , in *fig. D*, as in the last plate; then draw ordinates across the scroll at discretion, and take the length of the line  $d b$ , with its divisions on the longest side of the pitch-board, and lay it on  $d b$  in *E*; then the ordinates being drawn in *E*, it will be traced from *fig. D*, as the letters direct.

*How to find the parallel thickness of stuff.*

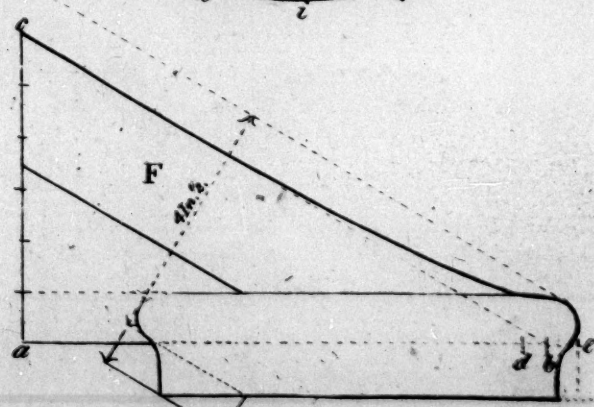
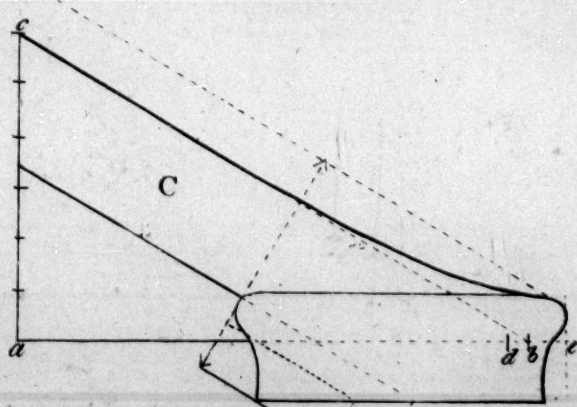
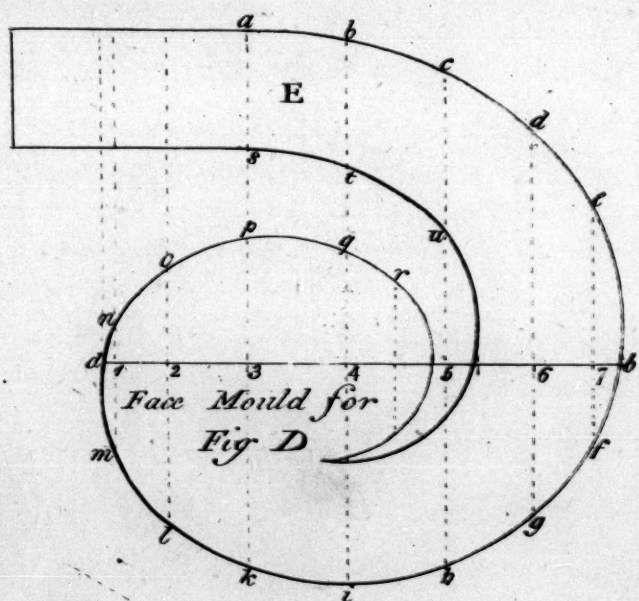
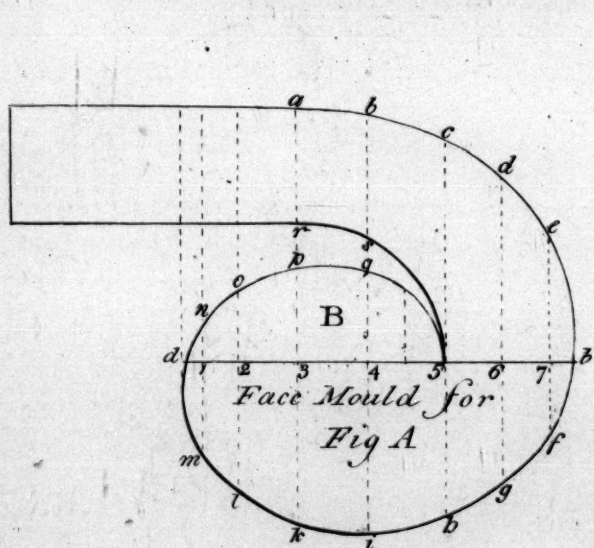
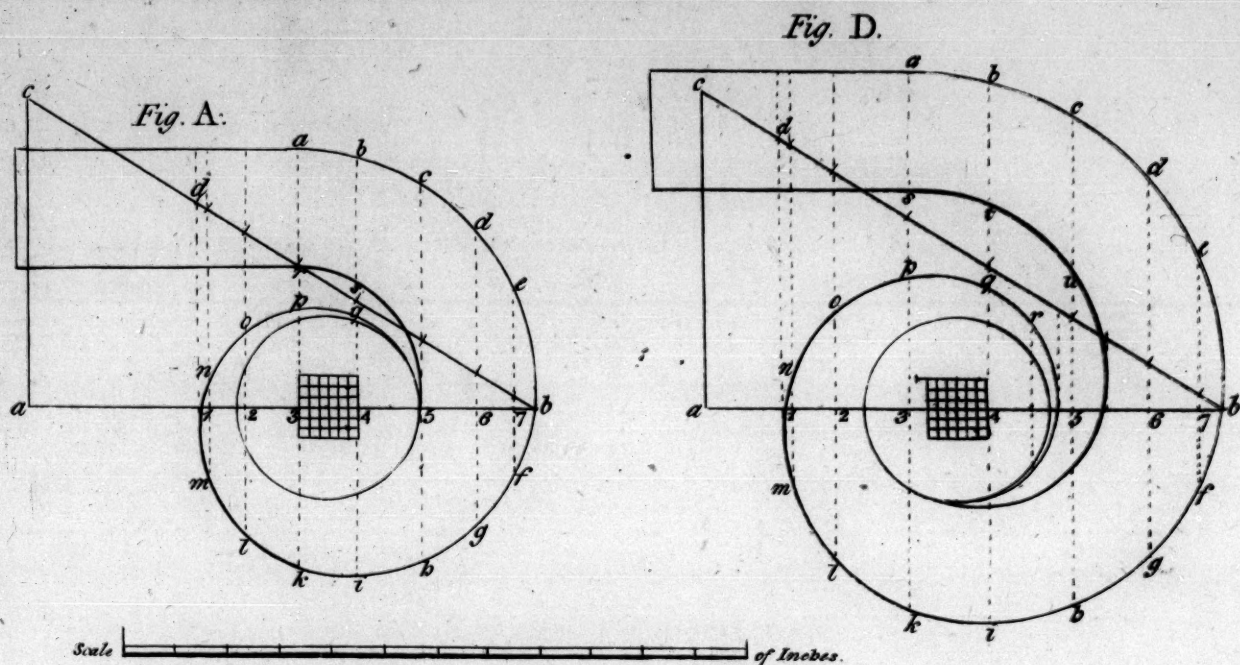
Let  $a b c$  be the pitch-board, in *F*, and let the level of the scroll rise one sixth, as in the last plate; and from the end of the pitch-board at  $b$ , set from  $b$  to  $d$  half the thickness of the ballister, to the inside; then set from  $d$  to  $e$  half the width of the rail; and draw the form of the rail on the end at  $e$ , the point  $b$  being where the front of the riser comes, then the point  $e$  will be the projection of the rail before it; then draw a dotted line to touch the nose of the scroll, parallel with  $c b$ , the longest side of the pitch-board, then will the distance between this dotted line and the under tip of the scroll shew the true thickness of stuff, which is nearly five inches and a half: but there is no occasion for the thickness to come quite to the under side; if it comes to the under side of the hollow, it will be quite sufficient, as a little bit glued under the hollow could not be discernible, and can be no hurt to the scroll, therefore a piece about four inches and a half will do.

**FIG. A** is a scroll of a smaller size, drawn in the same manner and with the same centres as the others are, but with a centre less. The method of finding the raking mould and thickness of stuff are the same as *fig. D*.



# Plate 55.

*This Shows how a Scroll is to be got out of the Solid .*



*Pub<sup>d</sup> as the Act directs Aug<sup>r</sup> 7. 1792 by P. Nicholson.*





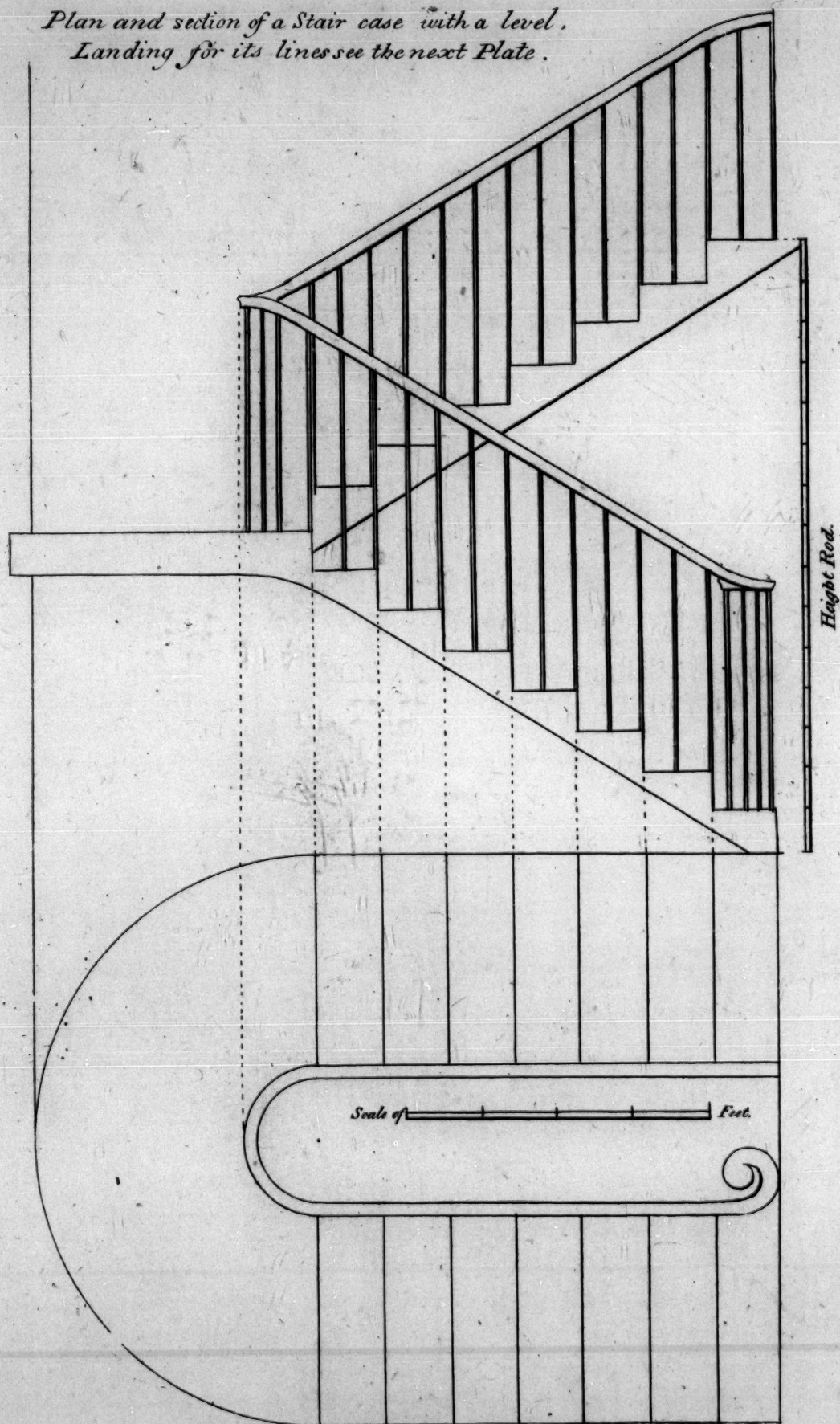






Plate 56.

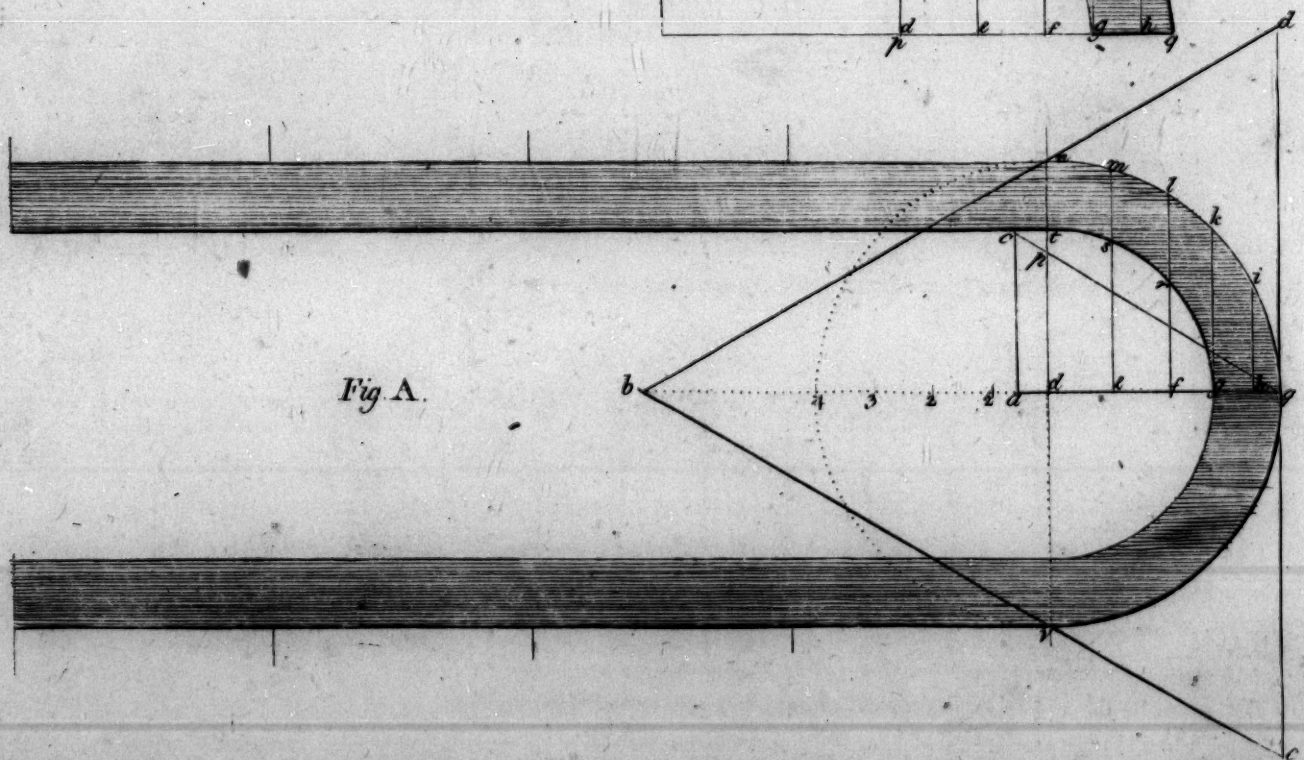
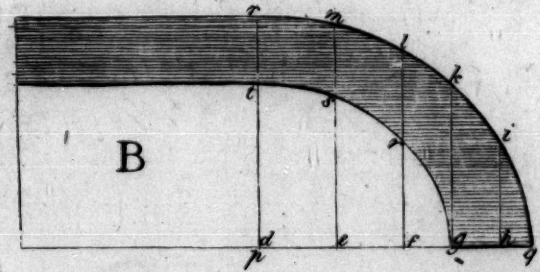
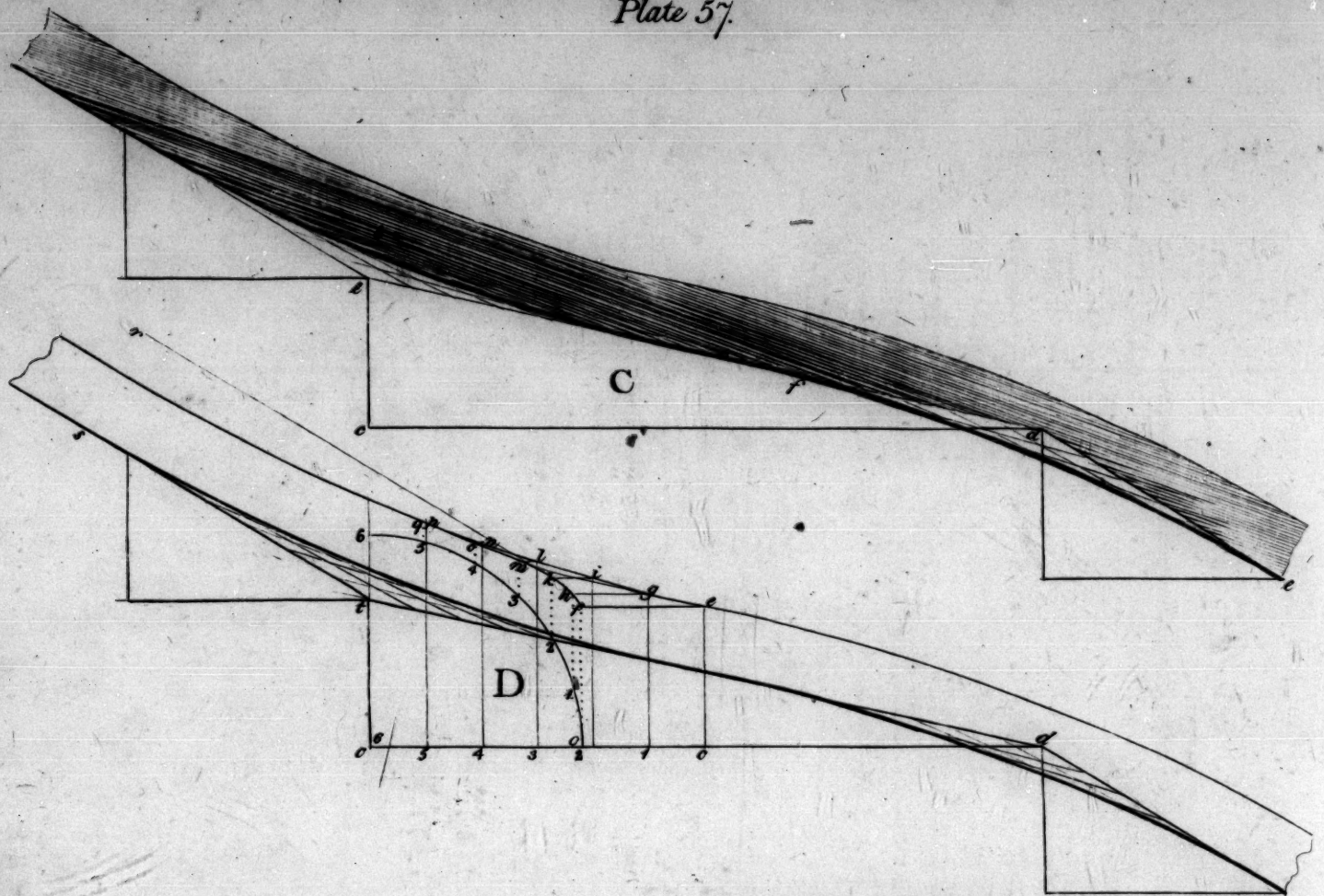
Plan and section of a Stair case with a level.  
Landing for its lines see the next Plate.













## P L A T E LVII.

*To find the face mould of a stair-case, so that when set to its proper rake it will be perpendicular to the plan, whereon it stands for a level landing, as is shewn in the last plate.*

In fig. A draw the central line  $bq$ , parallel to the sides of the rail; on the right line  $bq$ , apply the pitch-board of a common step; from  $q$  to  $a$  draw ordinates  $nd$ ,  $me$ ,  $lf$ ,  $kg$ , and  $ik$ , at discretion, taking care that one of the lines, as  $kg$ , touch the inside of the rail at the point  $g$ , so that you may obtain the same point exactly in the face mould; then take the divisions  $qhgfed$ , from  $q$ , and apply them at  $B$  from  $qhgfed$ ; from these points draw the ordinates of  $B$ , and prick them from the plan, as the letters explain; then  $B$  will be the mould required.

*To find the falling mould.*

Divide the radius of the circle into four equal parts, and set three of these parts from  $4$  to  $b$ ; through  $n$  and  $v$ , the extremities of the diameter of the rail, draw  $bn$  and  $bv$ , to cut the tangent line at the points  $c$  and  $g$ ; then will  $cd$  be the circumference of the rail, which is applied from  $c$  to  $d$ , at  $C$ , as a base line; make  $ce$  the height of a step; draw the hypotenuse  $ed$ , at the point  $e$  and  $d$ ; apply the pitch-board of a common step at each end of their bases, parallel to  $cd$ , make  $df$  equal to  $de$ , if it will admit of it, and by these lengths ease off the corners by the common method of intersecting lines; then draw a line parallel to it, for the upper edge of the mould.

*To find the parallel thickness of stuff.*

The same falling mould is again shewn distinctly at  $D$ ; bisect the line  $dc$ , at  $o$ ; divide  $ec$  into any number of parts, as 6; on  $c$ , as a centre, describe a quarter of a circle to the radius of the rail; divide the arch also into six equal parts; from the points  $cgiln$ , draw the parallel lines  $ef$ ,  $gh$ ,  $ik$ ,  $lm$ ,  $no$ ; from the equal divisions in the arch, draw the perpendiculars of  $1h$ ,  $2k$ ,  $3m$ ,  $4o$ , and  $5q$ , to intersect the parallel lines at  $fhkmog$ ; through the points draw a curve line; draw a right line  $rm$ , parallel to  $st$ , to touch the curve; then is the distance from  $r$  to  $s$  the parallel thickness of stuff.



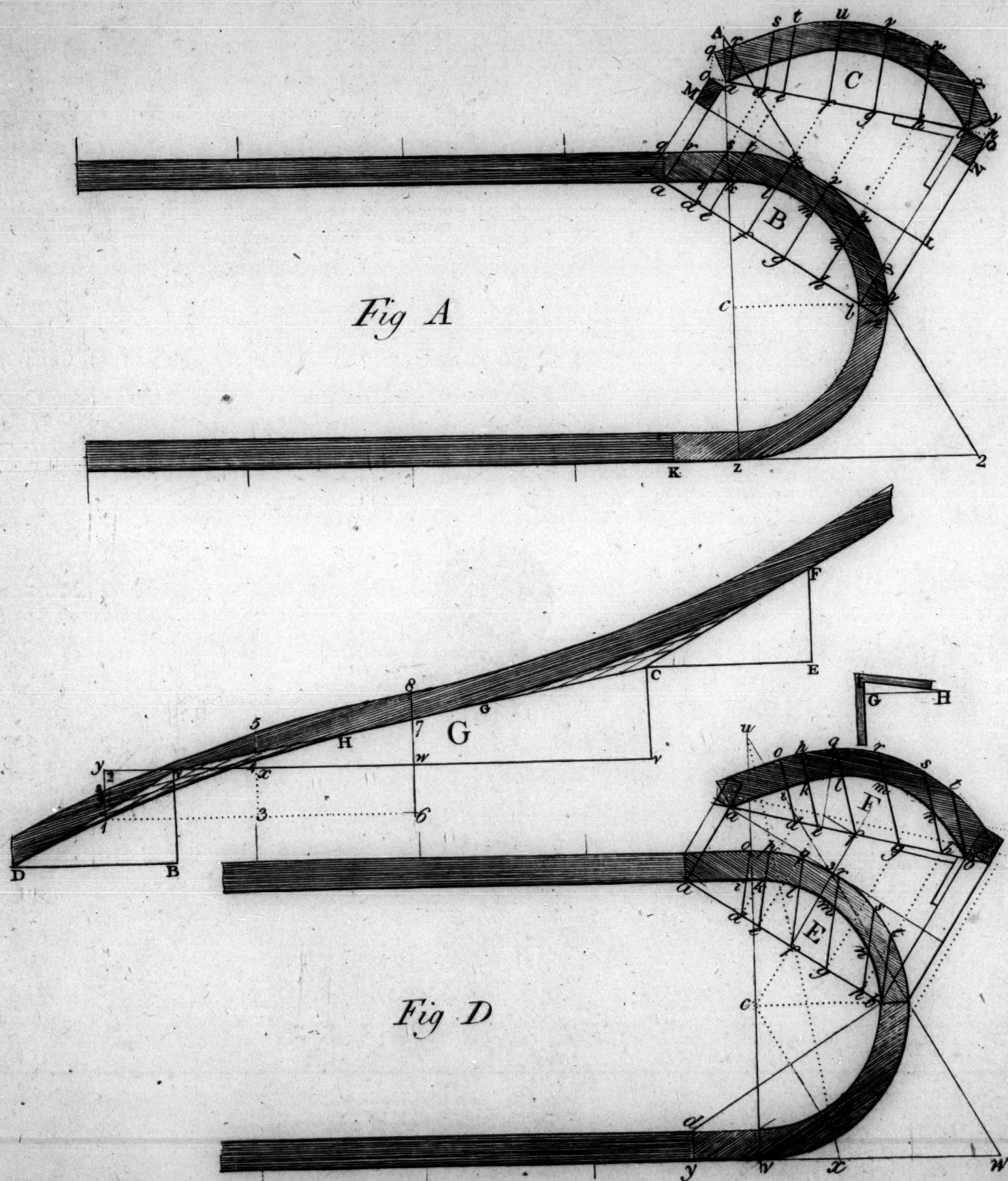
## P L A T E LVIII.

*To find a face mould of a rail for a large opening on a level landing.*

Let *fig. A* be the plan of the rail; through the centre *C* draw the diameter *z s*, and produce it to *A*; also produce the side of the rail out to *2*; then take the diameter *z s*, put the foot of your compass in *y*, and cross the line *A z* at *A*; through *A* and *y* draw the line *A 2*, cutting the side of the rail produced at *2*; then the distance from *z* to *2* is half the arch line of the rail; take the distance *z 2*, and place it on the right line *v v* at *G*, on each side of *w*, to *v* and *v*; draw *v B* and *v C*, each perpendicular to the right line *v v*, and equal to the height of a step; make *C E* and *B D* parallel to *v v*, each equal to the tread of a step; draw the hypotenuse *v c*, and the common pitch-boards *v B D* and *C E F*, at each end; make *v H* equal to *v D*, and *C G* equal to *C F*; and ease off the angles *G C F* and *D v H* by the common method of intersecting lines, which will give the curve of the under edge of the falling mould; draw a line parallel to it, equal to the thickness of the rail, will give the upper edge; produce the line *v v* out to *y*, from the middle *w* of the line *v v*, at *G*; make *w y* equal to *w y* at the plan *fig. D*; *y* being the place of the joint upon the plan, draw the line *y 2 1* perpendicular to *v v*, cutting the upper side of the falling mould at *2*, and the under side at *1*; from *1* draw the line *1 6*, parallel to *v v*, cutting the line *8 w*, produced to *6*; draw a tangent line *M L*; parallel to the chord *a b*, at the plan *B*, to the chord *a b* draw any number of indefinite perpendiculars, observing to draw a perpendicular through every joint, as from the joint *a q* and *b y*; then take the distance *1 2* from your falling mould at *G*, and set it from *M* to *o* of the plan at *B*; also from *L* make *L N o* equal to *6 7 8* at *G*; then the shaded parts at *N o* and *M o* are sections of the rail; then draw a line *o b*, to touch the corners of the sections at *o* and *b*; at the points *o, a, d, e, f, g, h, b*, and *p*, draw perpendiculars to *o b*; then *C* being pricked from the plan at *B*, as the letters direct, will be the true face mould.

FIG. *D* is a plan of the same size, shewing the face mould at *F*, when sprung, which will be a very great saving of stuff; and not much more trouble in laying it down when properly understood. This method will be clearly explained in the following pages.















*Plate 59.*

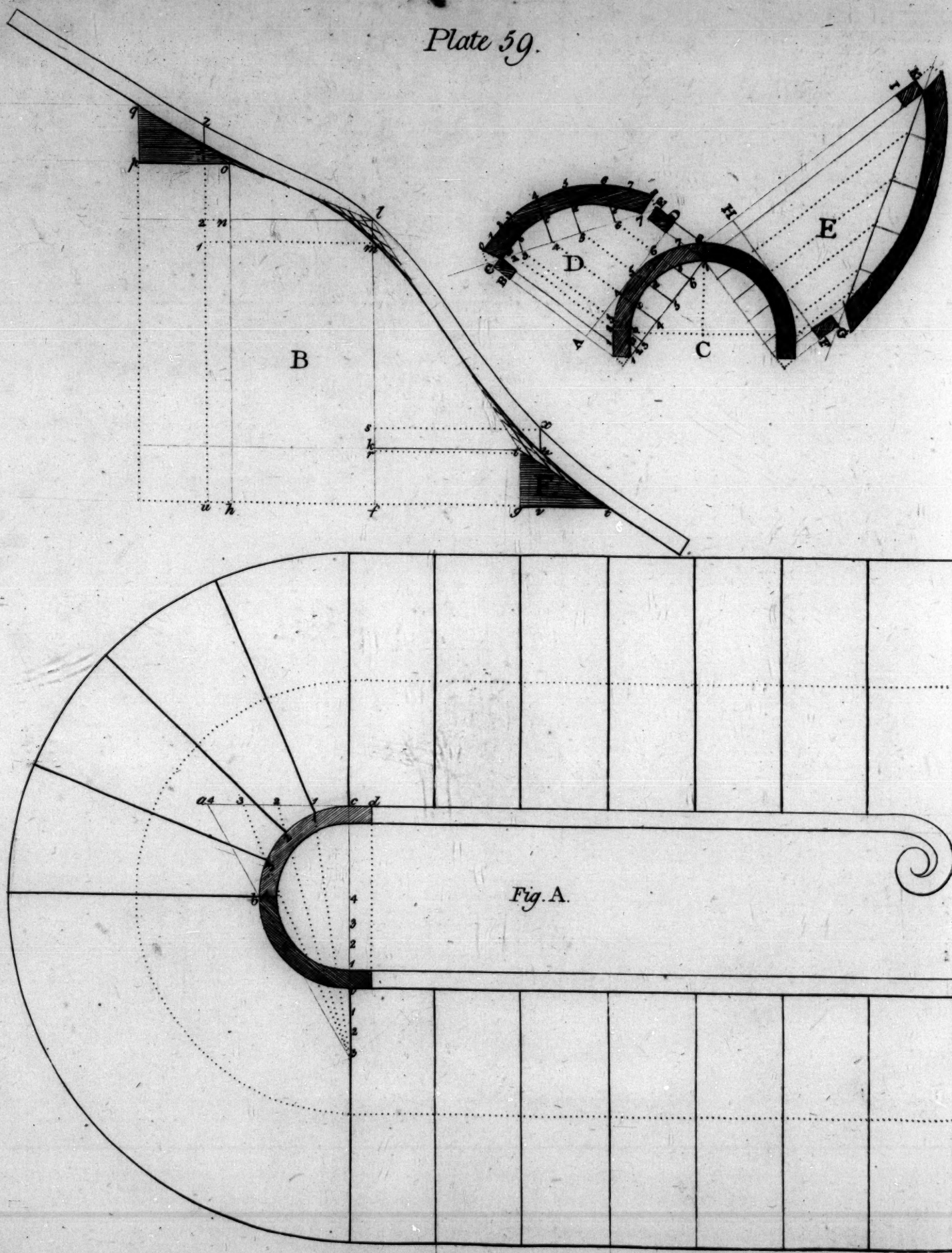
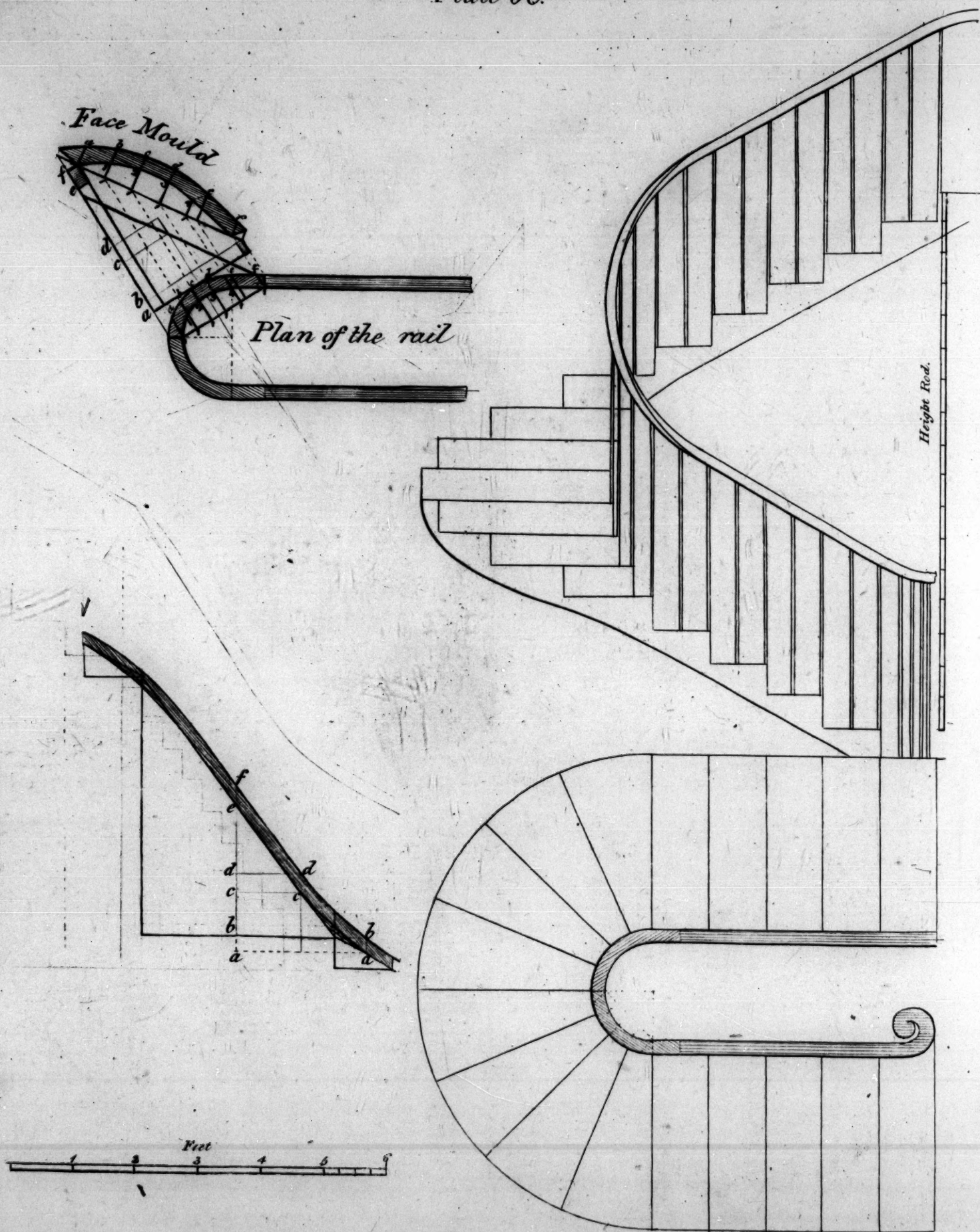








Plate 60.





## P L A T E LIX.

*To draw the falling mould of a rail having a quarter space in it; thence to find the face moulds of the circular part.*

At the plan *fig. A*, *a c* is the stretch out of half the circular part of the rail, found by the same method as in the foregoing plates; or it may be found more exactly thus: Divide the radius into four equal parts, and set three of the divisions out to 3, and draw a line from 3 to *b*, cutting the side of the rail produced at *a*\*; from the point *f* in the right line *b g* at *B*, make *f b*, and *f g*, each equal to the stretch out of half the rail, that is, equal to *a c*, *fig. A*; draw the perpendiculars *b o*, *f l*, and *g t*; at *B* apply the pitch-board of a common step at *F*; through the point *t*, draw *t k*, parallel to *g b*, cutting the line *f l*, at *k*; from *k* to *l* set up the height of the four winders; through *l* draw *l n*, parallel to *g b*, cutting the line *b o*, at *n*; from *n* make *n o*, equal to the height of a step, for the quarter space upon the landing which only rises one step; draw the hypotenuse *l o*; again, draw *o p* parallel to *g b*, and *p q* perpendicular to *o p*, draw *q o*; then *o p q* is the pitch-board of another common step above the winders; then these angles being eased off by the method of intersecting lines, the falling mould will be completed, as in the last plate; make *f u* and *f v*, from *f*, equal to *a d*, *fig. A*, that is, the stretch out from the middle of the arch at *b*, to the joint; draw *v x*, and *u z* parallel to *f l*; then take the heights from *x* to *y* and *z*, and set them from *A* to *B* and *C*, will give the section *B C*; then take *m l* from the falling mould, and from *D* make *D E* equal to it, will give the section *D E*; then take *w x* from *B*, and make *F G*, at *E*, equal to it; from *w*, draw *w r*, parallel to *g b*, cutting *f m* at *r*; from *r* take the heights from *m* and *l*, and set up these heights from *H*, to *I* and *K* at *E*, it will give the section *I K*; then the face moulds upon *D* and *E* will be traced as directed in the last plate.

\* The line *a c* is nearly equal to the semicircumference, and is the most exact of any that ever has yet been shewn by a geometrical method; it may be depended on in practice; it is absolutely impossible to find a right line exactly equal to the circumference of a circle; this has exercised the attention of the greatest mathematicians in every age.

---

PLATE LX. wants no explanation.

PLATE



(4) THE THEORY AND PRACTICE OF JOINERY.

P L A T E L X I.

*To draw a falling mould for a rail having a winder all round the circular part, as is shewn in the last plate, thence to find the face mould.*

To describe every particular in this, would almost be repeating what has been already described in the last plate; the heights are marked the same upon the falling mould at *D*, as they are at the face mould, which will give the heights of the sections of the rail; and the face mould at *C*, is traced from the plan *B*, according to the letters; In plate 60 is shewn the same thing, only with this difference, that the face mould is partly straight at one end, because the joint must have been weaker, had it been made where the circular part of the rail begins, as is shewn in this plate; but the method of tracing this is nothing different from the other in the last plate: Only I would have the reader to observe, in plate 60, that ordinates are drawn through the places where the circular part begins, which will give the same points on the face mould; for, by this means, you will be able to determine what part of the face mould is exactly straight, and where the crooked place of your mould begins. I hope the reader will understand the same thing in the following plates, without being told a second time. *G* shews the application of the mould to the plank; take the bevel at *H*, and apply it to the edge of the plank at *D*, and draw the line *b c*; then apply your mould to the top of the plank, keeping one corner of it to the point *B*, and the other corner close to the same edge of the plank; then draw the top face of the plank by your mould; then take your mould, and apply it to the under side at *c*, in the same manner.



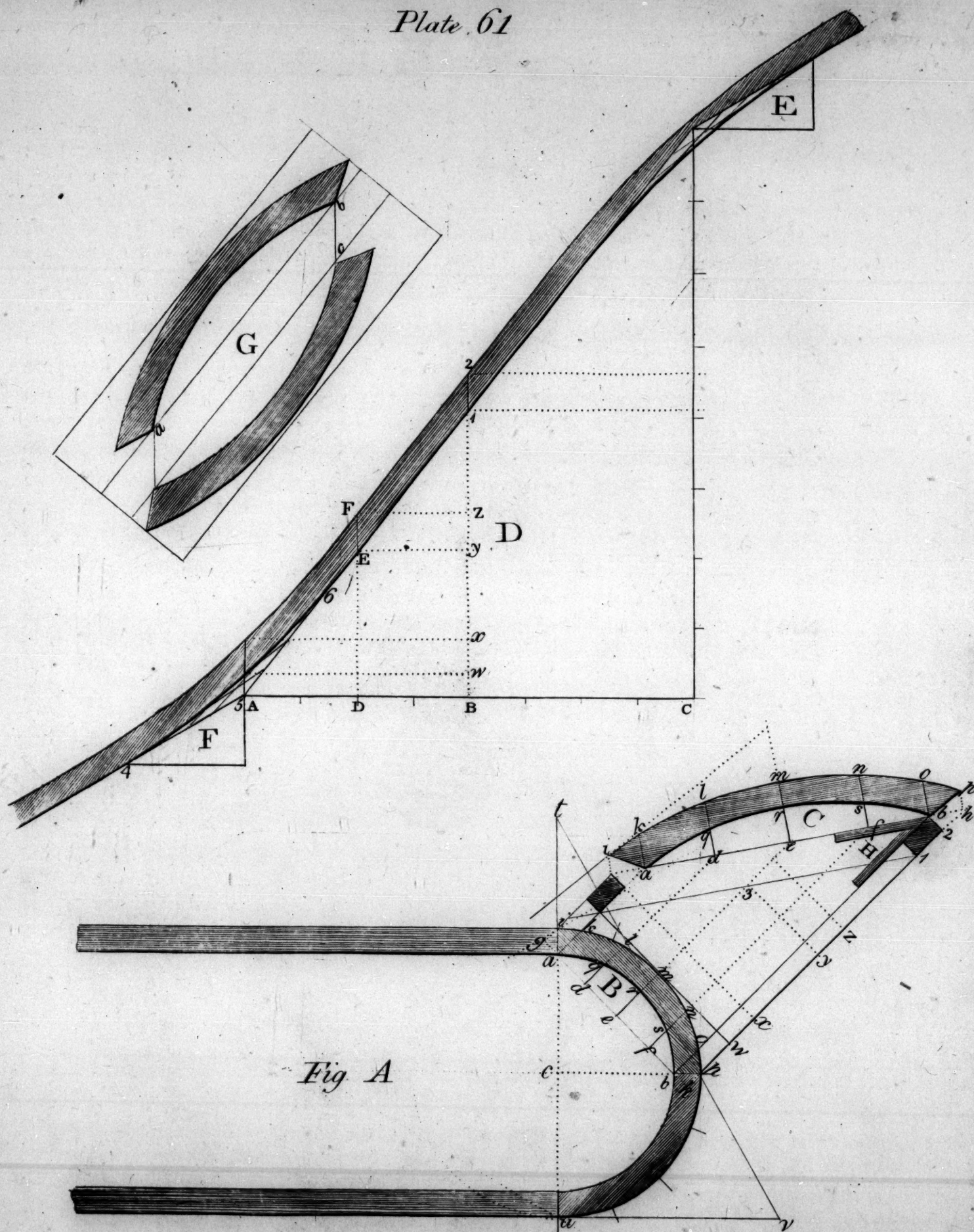






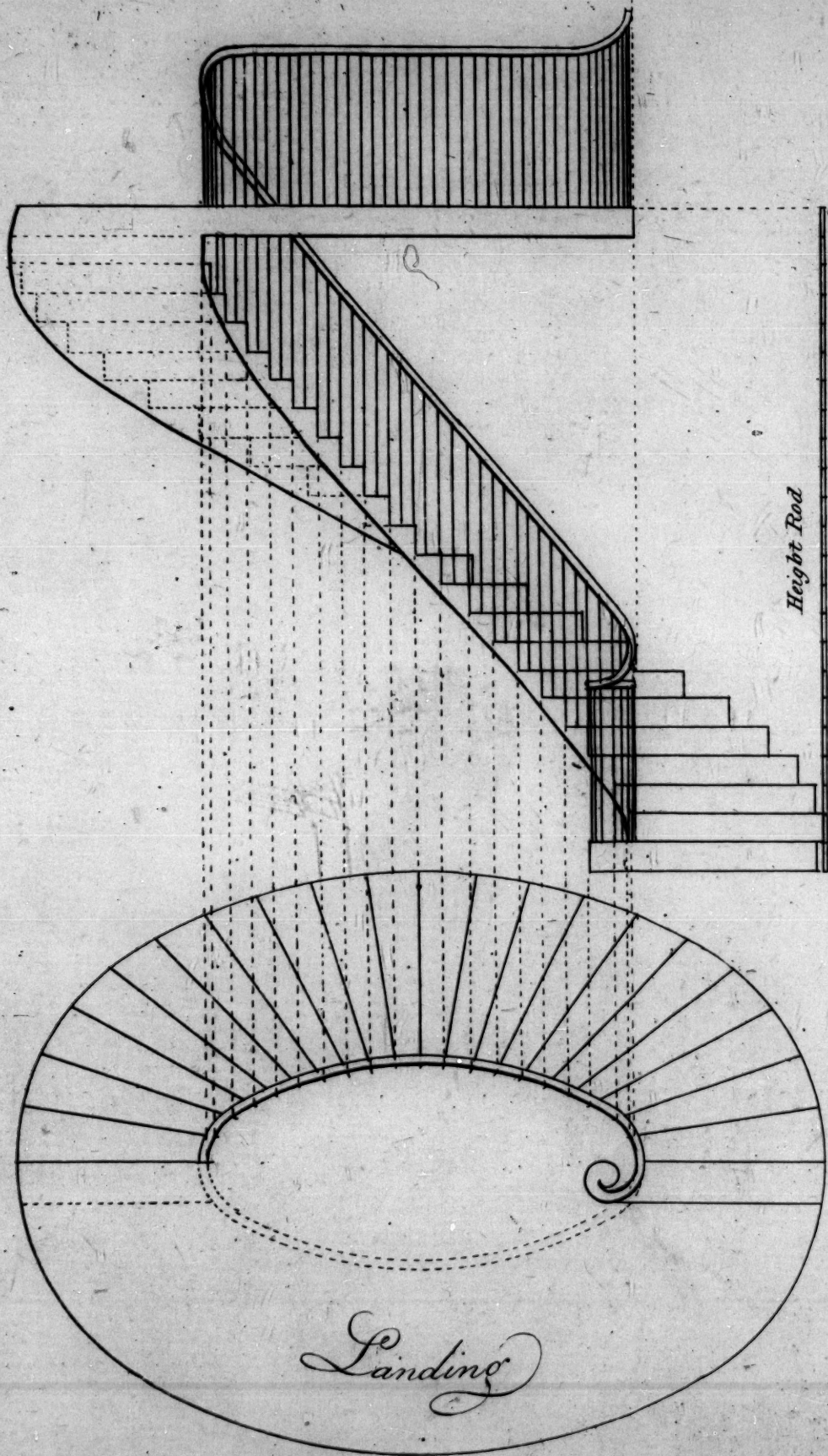






Plate 62.

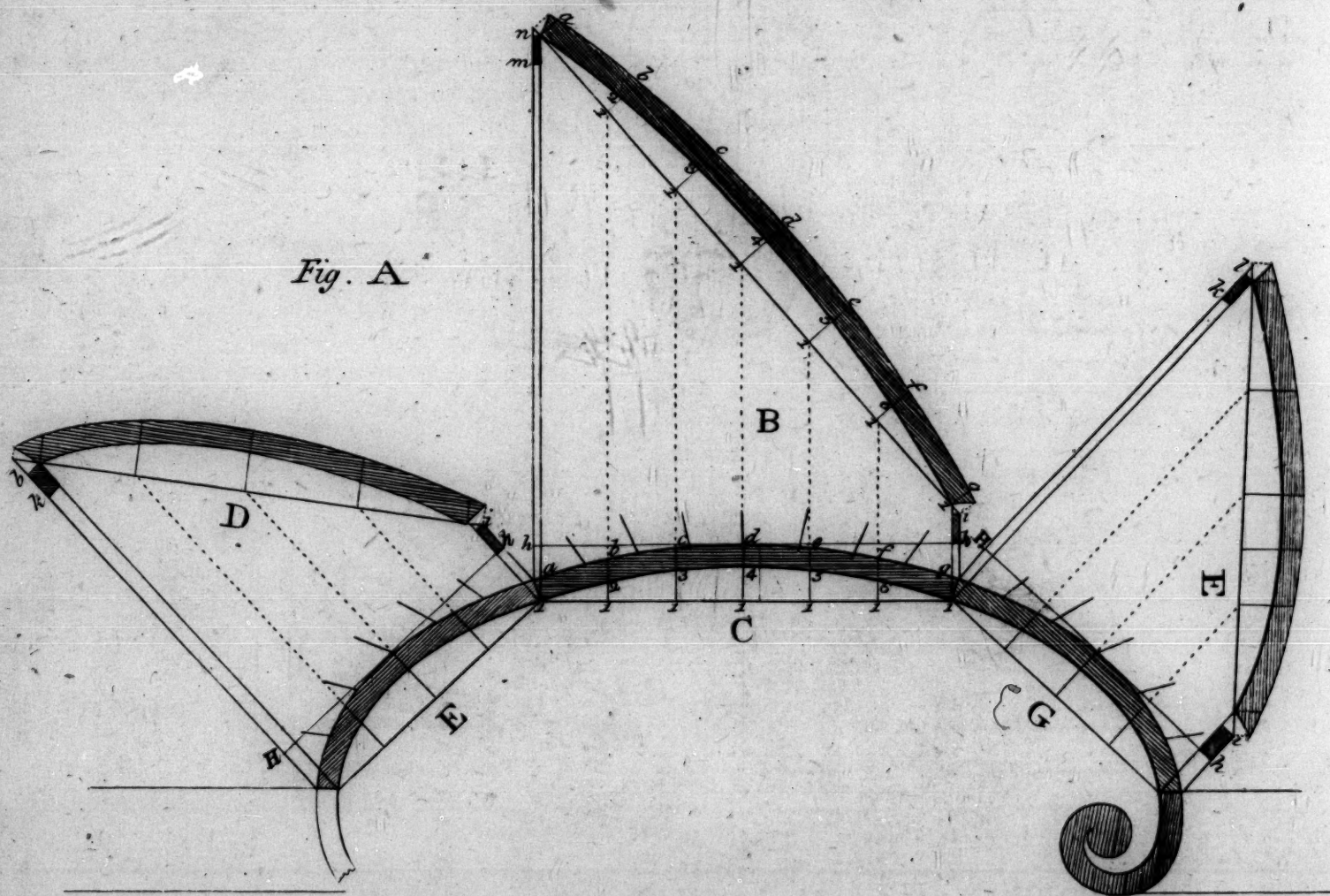
An elliptical Plan & section of a stair case. For its lines see the next Plate













## P L A T E LXIII.

*How to draw the face moulds of an elliptic stair.*

The plan and section being laid down as in plate 62, the reader will observe, that the ends of the steps are equally divided at each end; that is, they are equally divided round the elliptic wall, and also at the rail. In this plate, the rail is laid down to a larger size than that in the last plate; the plan of this rail must be divided round, into as many equal parts as there are steps; then take the treads of as many steps as you please, suppose 8, and let  $h b$ , at *fig. H*, be the tread of 8 steps from  $H$ ; on the perpendicular  $h m$ , set up the height of as many steps, that is, 8; and draw the hypotenuse  $m b$ , which will give the under edge of the falling mould. The reader will observe, that this falling mould will be a straight line, excepting a little turn at the landing and at the scroll, where the rail must have a little bend at these places, in order to bring it level to the landing and to the scroll; then mark the plan of your rail in as many places as you would have pieces in your rail (in this plan are three); then draw a chord line for each piece to the joints; also draw lines parallel to the chords, to touch the convex side of the plan of the rail; from every joint draw perpendiculars to their respective chords. Now the tread of the middle piece at  $C$  being just 8 steps, the height of the section from  $b$  to  $m$  is 8 steps; and the section  $m n$  is the same as  $m n$  on the falling mould, and the section  $b i$  is the same height as  $b i$  upon the falling mould; then draw a line to touch the sections, and complete your face mould as in the foregoing plates, each of the other pieces at  $F$  and  $G$ , the treads, being six steps; therefore, from your falling mould set the stretch of 6 steps; from  $b$  to  $H$  draw  $H l$ , parallel to  $b n$ , then  $H k l$  will give the heights of the sections at  $D$  and  $E$ ; every thing else agreeable to the letters.

*Note.* By the stretch out of 8 steps, or any other number, is not reckoned on the chord; but it is the stretch out round the convex side of the rail, or what some people call the inside.



# THE THEORY AND PRACTICE OF JOINERY.

## PLATE LXIV.

*The tread of a winding stair being given, round the middle and the plan of the rail; to diminish the ends of the steps at the rail, so that the balusters shall be all regular, or of an equal height, when finished.*

Let the first winder begin about the first step before the circle of the rail, at *D*; from *a* to *e*, in the plan *fig. A*, is the stretch out of half the circular part of the rail; the method of finding it has already been explained in the foregoing plates; from *e* draw *eH*, perpendicular to the side of the rail; by reckoning round the dotted line, from 5 to 10, you will find there are five treads, or five winders; therefore from *q* to 5 set up the height of 5 steps; produce the longest side *ab* of the pitch-board *D*, to *c*; bisect *bc*, at 2; draw a line from 2 to 5; then divide 2 *b* and 2 *5*, each into the same number of equal parts; and intersect the angle by the common method of intersecting lines, will give the under edge of the falling mould; then a line being drawn parallel to it, to the thickness of the rail, will give the upper edge, which is the falling mould for half the rail; draw the lines 1 *l*, 2 *k*, 3 *i*, and 4 *h*, parallel to 6 *g*, to intersect the falling mould at the points *h*, *i*, *k*, *l*; from these points draw the parallel dotted lines to *qH*, down to the rail at *t v u*; from *c* draw *cs*, *ct*, *cv*, and *cu*, cutting the arch line of the rail *m, n, o, p*, will give the ends of the steps at the rail; then draw lines from *m, n, o, p*, through 6, 7, 8, 9, will be the plan of the steps.

*To find the face mould of a rail, so that it may be got out of the least thickness of stuff possible.*

Lay down the plan of the rail at any convenient place, as No. 3; draw the chords of the rail *no* and *op*, from the centre *K* draw *KE*, perpendicular to the chord *no*, cutting the outside of the rail at *c*; in the same manner draw the chord *w x*, at the plan, *fig. A*; from the centre *g*, draw *gf* perpendicular to it, cutting the outside of the rail at *f*; from *c* draw a line *cf*, to cut the tangent line at *v*; draw a line *ve*, parallel to *qH*; from the joint of the rail at *b* draw *bB*, also parallel to *qH*, intersecting the under side of the rail at *A*, and the top side at *B*; draw from *A* a line *AF* parallel *bq* from *F*, at No. 3; make *FGH* equal to *FGH*, at No. 1; from *C*, at No. 3, make *CDE* equal to *CDE*, at No. 1; and make *AB*, at No. 3, from *A*, equal to *AB*, at No. 1; draw a line *BR*, for the chord of the mould to touch the shaded sections, perpendicular to *no* and *AF*; from *E* draw *EM*, perpendicular to *BR*; make *ci*, at No. 2, equal to *ic*, at No. 3; make *ie* perpendicular to *ci*, equal to *EL*, at No. 3; make *LM* equal to *ce*, at No. 2; from *E* draw *ET*, parallel to *AF*, cutting the chord line *BR* at *T*; from the points *T* and *M*, draw the line *TM*, then *TM* will be one of the ordinates; all the other ordinates are drawn at discretion, parallel to it, and completed in the same manner as is shewn in plate 9, for the sections of a cylinder.

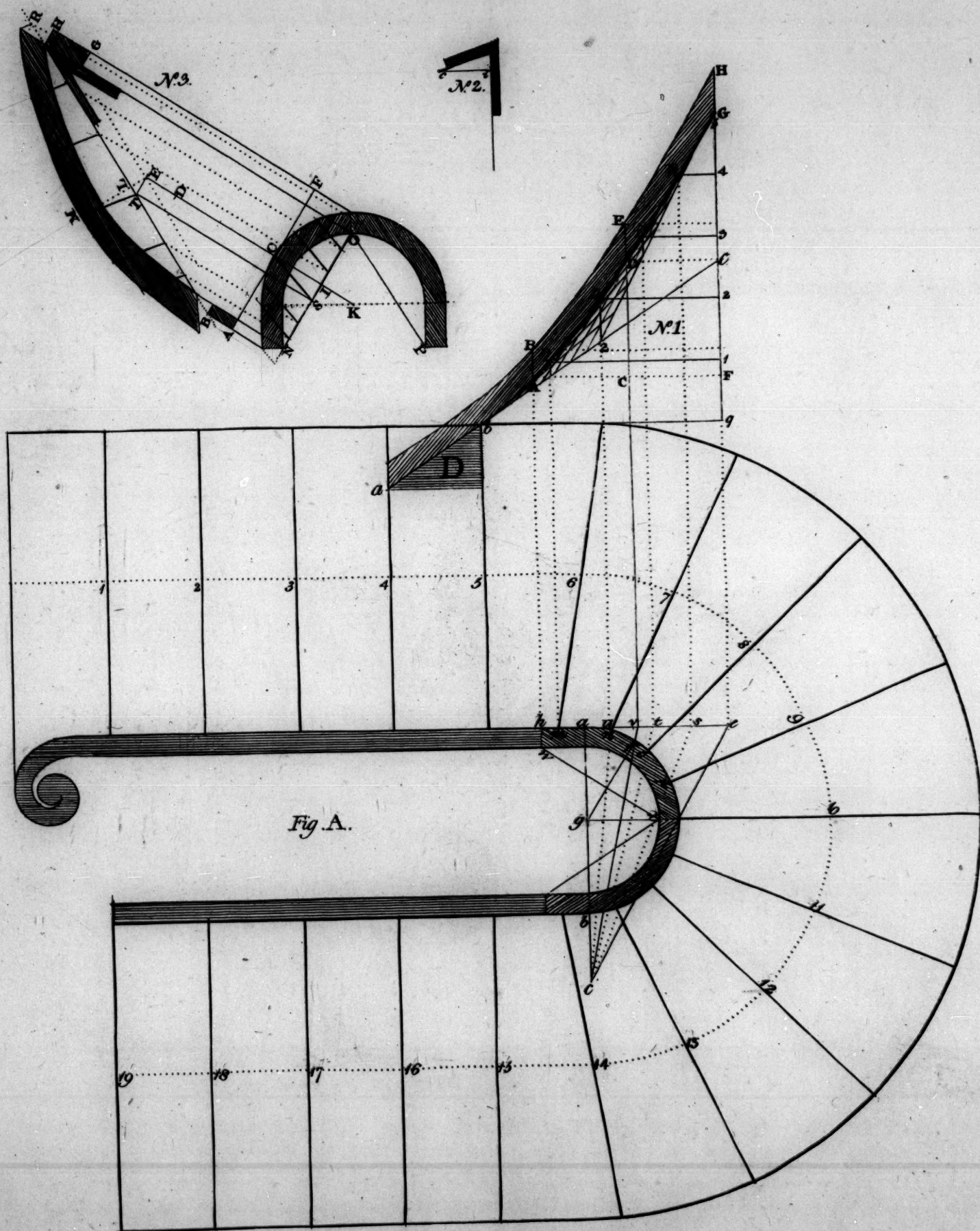
The reader will take notice, before the face mould at No. 3 can be applied, the edge of the plank must be first bevelled according to No. 2; then the plumb-line will be drawn on the bevelled edge of the plank, by the bevel that is drawn at No. 3.

*Note.* By this method of proceeding, a three inch plank will almost be sufficient for any rail of this kind however it ramp; whereas in many cases, by the common method, it may require a plank five or six inches thick. Many other advantages will attend the manner of setting out this plan; I shall mention one or two: in fixing the bannisters, they will be all regular, and the string board will be as easy as the rail itself; the skirting will also be quite regular, for the ends of the steps are wider and wider as they go round to the middle of the semicircle; lastly, a blacksmith may put up an iron rail with very little trouble, the bannisters being all regular; whereas no other plan will admit of it, unless it is set out in this manner.

PLATE



Plate 64.



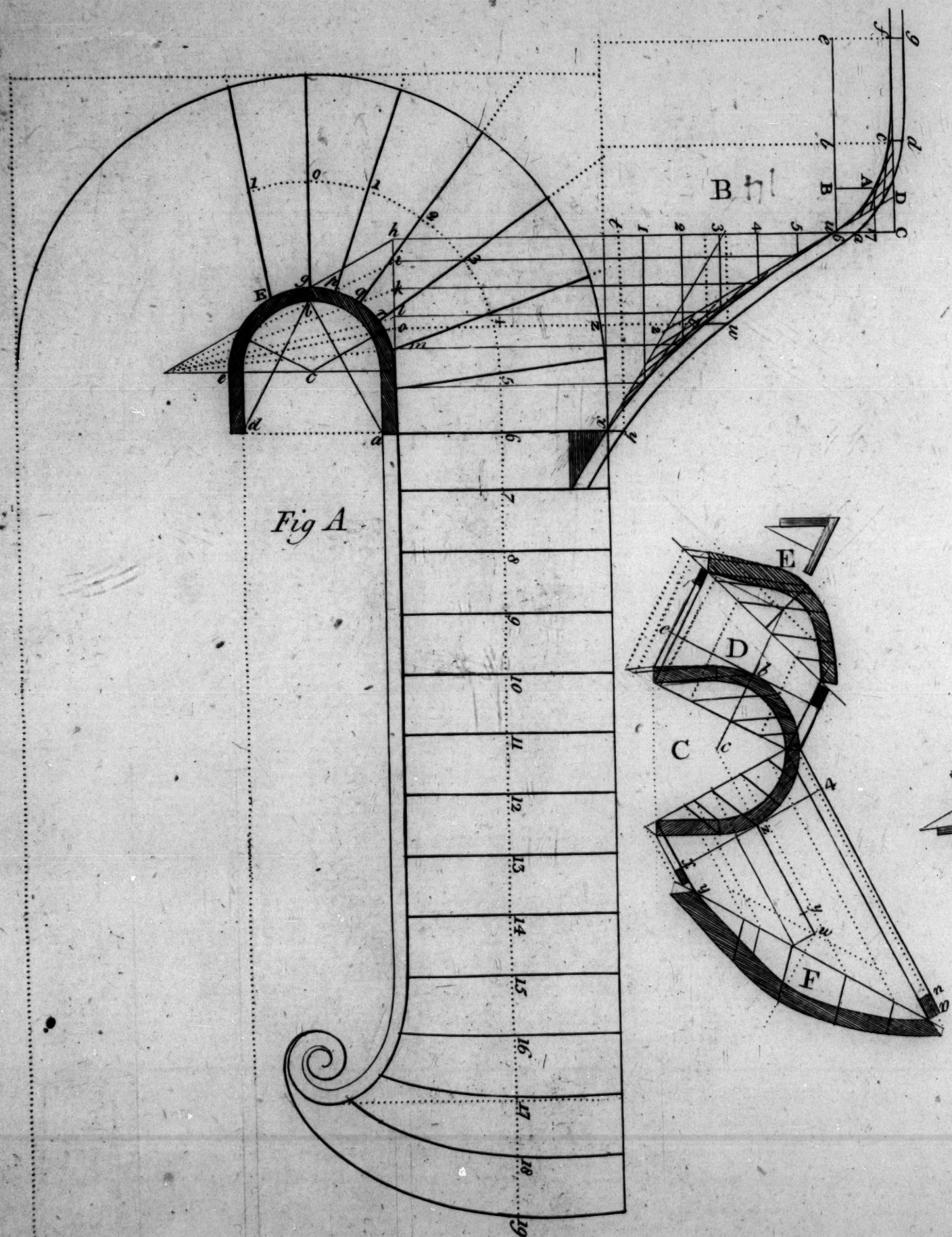














## P L A T E LXV.

*To diminish the step of a stair winding round one of the quarters to a level landing.*

Find the stretch out round half the circular part of the rail, as directed for the foregoing plates, and complete the falling mould as directed in the last plate, for the winding part of the rail, which is six steps from *t* to *w*; in order to bring the rail with an easy turn round to the landing, set off the height of another step from *u* to *7*, and let the under edge of the rail be half the height of a step above that to *c*; or it may be more, according to the discretion of the workman; then the rail will be half the height of a step more upon the landing than it is upon the winders; through *c* draw *cf*, parallel to the base, and continue the line *2 u*, that forms the intersection below for the winders up to *D*, and ease off the angle *u D c* by intersecting lines, will give the under edge of the mould turning up to the landing: in order that the last step beyond the quarter should also follow the mould, draw a line through *7*, the height of the last step, parallel to *u b*, or *c c*, cutting the under side of the falling mould at *A*; through *A* draw *AB*, parallel to *c t*; then *u B* is the tread of the last step at the rail, which is set from *g* to *E*. The face moulds at *D* and *F* are completed in the same manner as directed in the last plate, and the mould in plate 58, at *fig. D*, is also laid down by the same method, the height of the sections being taken from the falling mould that corresponds to that place of the rail which the face mould is made for; and the bevels that are laid down above each face mould will shew how much you must bevel the edge of your plank, before you can apply the face moulds to the plank; then draw the plumb of your rail, upon the bevelled edge, by the other bevels that are shewn at the sections; then apply your mould to each side of the plank, keeping it fair with the bevelled edge, the same as in other cases before mentioned.



## P L A T E LXVI.

This plate shews the method of capping an iron rail, upon much the same principles as the others, but with less trouble.

*How to find the thickness of stuff for capping of an iron rail.*

Lay a thin broad piece of wood, as *b*, upon the top of the iron, upon the place that is to be capped, and turn it round upon the iron, till you see the greatest space between the iron and wood to be as little as possible; then the open space will shew what thickness must be added to the thickness of the rail.

*How to find the plumb of the piece, for the application of your mould.*

After having found what thickness of stuff will do, apply the solid piece itself, *b*, to its place, then let one of the ends, as *d e*, be cut plumb.

*How to trace the under side of the plank to the iron, instead of the face mould.*

Make a pricker, as *c*, with a steel point in the upper end, and let it be notched out, so that when it is applied on each side of the ballister, it may just leave the thickness of the rail between each point; then take your pricker *c*, and prick your piece *b*, at every ballister; always keeping your pricker close to every ballister. This being done both outside and inside, if you inspect *C*, it will make it plain, where you see the sides of the plank flatted out, which shews upon the under side at the black dots; strike a plumb-line *d e*, upon the end of your plank *b*, and this plumb-line will shew how the top is to be pricked off from the bottom, which you see at *C*; the under side is squared over to the edge, from your pricked points, and from thence drawn across the edge to the rake, which is formed by the plumb upon the edge, then squared over the top side, and then it is to be pricked off from a line drawn from the point *d*, in the end section *D*, which the plumb-line gives upon the end, along the top face of the plank, parallel to the edge, and not from the square edge of the plank.



Plate 66.

*This Plate shows the method of capping  
an iron rail*

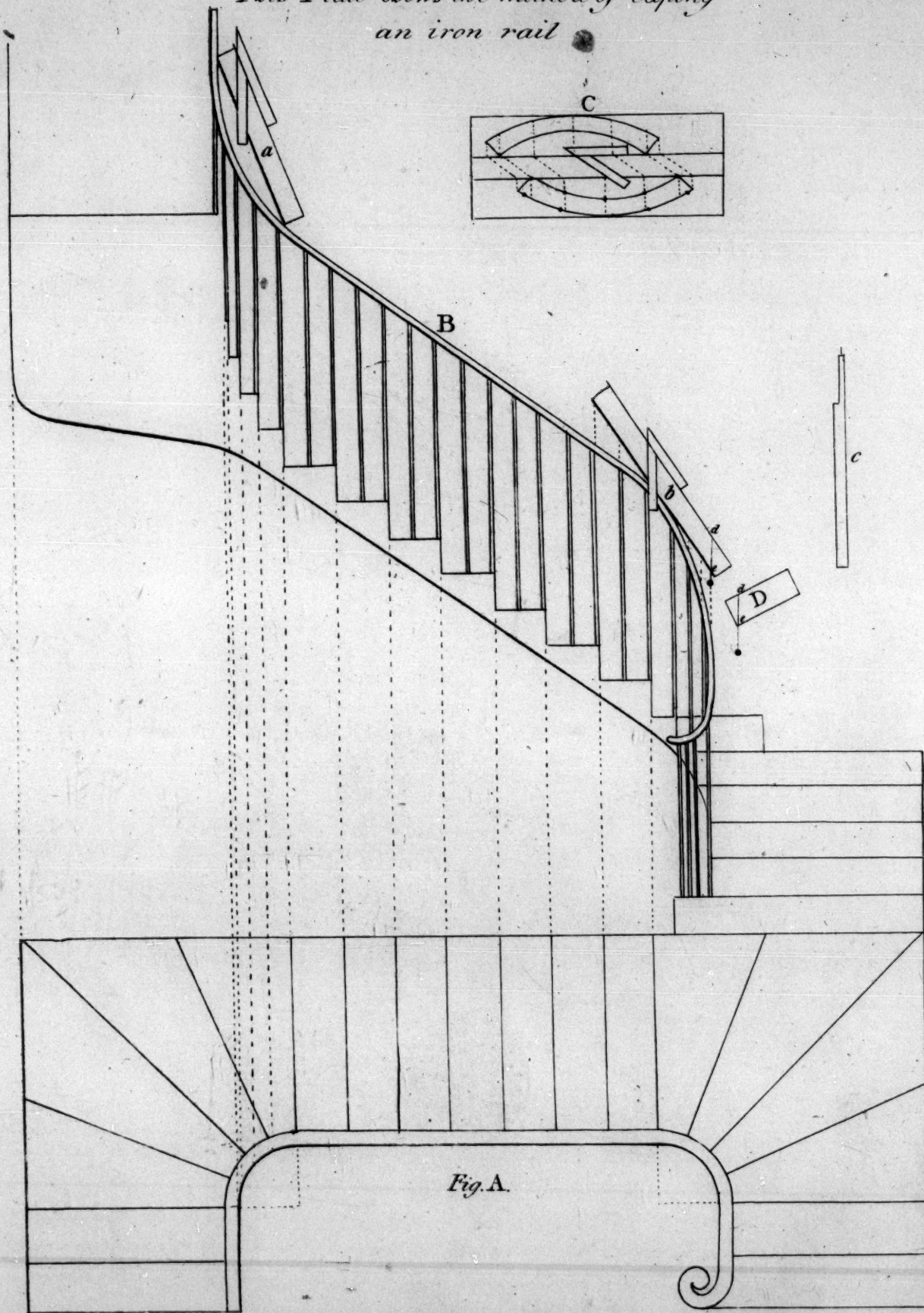






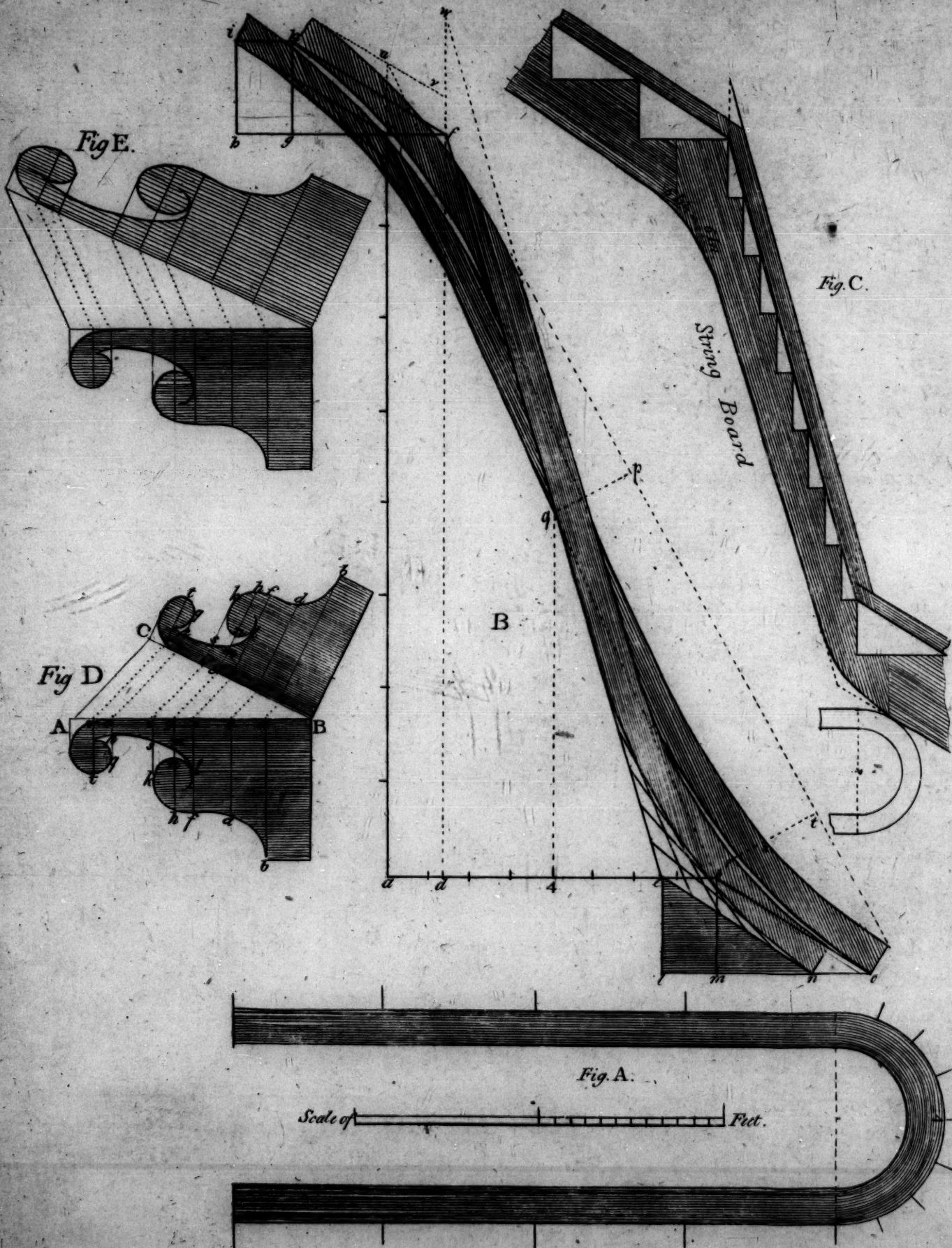






Plate 67.

This Shows how to glue a Rail in Thickness.





## P L A T E LXVII.

This plate shews the method of gluing a rail in thicknesses; but if I must give my opinion, a rail got out of the solid is much more preferable, although you are obliged to have more end joints in it; but if your joints are well screwed together, a solid rail has a more beautiful appearance than a rail glued up, having so many different thicknesses of glue, which makes it have a black and nasty look with it; if a person is ever so careful, the joints will still shew, and this rail in itself having a natural tendency to spring, the least dampness will make it give way in time; but as this is held by some a very valuable acquisition, I shall proceed to lay down the moulds for it.

*To shew the application of the outside and inside falling moulds to the upper and under faces of the plank, to give it the form of the twist.*

$A b$  is the stretch out of the greatest circle in  $B$ , and  $a c$  the height of the steps; again,  $d e$  is the compass of the lesser circle, set in the middle between  $a b$  and  $d f$ , the height of the steps, the same with  $a c$ : therefore the triangle  $a b c$  is the pitch-board of the inside falling mould; and  $b m o$  at the bottom, and  $i h c$  at the top, are the pitch-boards of two common steps; which lines, when intersected, will give the under line of the inside falling mould. In the same manner  $d f e$ , with the two common steps  $k g f$  at the top, and  $e l n$  at the bottom, will give the under line of the outside falling mould. The top lines are only drawn parallel to the under lines to the thickness of the rail.

*How to apply these moulds to the plank.*

Draw a line  $t p$ , to touch the moulds so laid down in two places, and as both moulds intersect together at  $q$ ; then draw a square line  $p q$ , upon the top of your plank, at the same distance as  $p q$  is from the bottom ends of your moulds, and this line being squared across the edge, and from thence across the under side; then set the distance  $p q$  on both sides of your plank, from the same edge, and likewise square over  $t s r$ , at the distance  $p t$  on your plank, on both sides, then set the distance of  $r$  from  $t$  upon the top side of your plank, and set the distance of  $s t$  upon the under side; you will observe to mark the point  $q$  upon both your moulds, then apply your outside falling mould to the top of your plank, making the point  $q$  to coincide with the same point  $q$  in the plank, and make the front of the falling mould to come to  $r$ , and with this mould, placed in this position, draw the upper face of your plank with it, and in like manner apply your inside falling mould, that is, by applying the point  $q$  to the same point  $q$  in the plank, on the under side, and let the front edge be to  $s$  in the plank; then draw the under side; your plank being supposed of a sufficient thickness, making allowance for the saw cuts, and planing up your veneers, this plank, when cut out twisted to those lines will be the true form of your veneers: the piece being thus formed, you are to cut your veneers the other way into thicknesses as you think they will bend easy, and so I shall leave you to complete the rail.

There is one thing that I would have you take notice of here, the general custom among workmen to keep the hand rail highest upon the winding part of the stairs, on the supposition of a person coming down stairs being liable to fall over the rail, when the descent is very rapid; and therefore to remedy that inconvenience, I have all along made the under side of the falling mould, or the under side of the rail, which is the same thing, to be equidistant upon the rake from the face of the risers, which will cause the upper side of the rail to run higher on the rake, than the height of the rail above the common steps, and the quicker the ascent is, the difference will be greater. In laying down this, the distance  $v w$  shews how much the winding part rises above the common steps, which is about five inches and a half; this is done by continuing the top line of the rail upon the winding part to  $w$ , and by continuing the top of the straight part to meet at  $v$ , then the distance of  $v w$  will always be according to the pitch of the winders.

P L A T E



## P L A T E LXVIII.

This plate shews the method of fitting down the skirting, upon any sort of a stair-case whatever; whether straight, circular, regular, or irregular; if the treads are ever so crooked, and the risers out of an upright.

In *fig. A*, is shewn a bevel, made to the rake of the skirting, and the other perpendicular to the stair, and a sliding piece to be applied to the perpendicular side of the bevel, with a hooked point of iron or steel, to stand forward at the bottom so much, that the sliding piece may clear the nosing of the step. I shall proceed to shew its application.

*How to fit down the skirting.*

Lay the skirting over the top of the steps, and let a very fine notch be made on the front edge of your sliding piece, to the height of a step, or rather higher; then apply the point of the sliding piece to the internal corner of a step, and prick your skirting in the notch at *b*, the bevel being supposed to be brought close to the slider: again, supposing you want to take a point at the nosing, where you see the bevel applied under, apply the point of your sliding piece to the nosing at *c*; then prick your skirting in the notch at *d*, that will give the point *d*, which is to correspond with *c*, &c. and by this means you may take as many pricks as will be sufficient, till the whole is completed.

**COROLLARY.** Hence it is evident by the same method, that one thing may be fitted into another, whether considered as a stair-case or not, standing either raking, horizontal, or perpendicular.

If the steps of a stair-case be very true, two pricks from each riser and tread will be sufficient, as it is only joining these pricks by lines, which will form the rise and tread of each step, and three pricks in each nose, because a circle may be easily drawn through the three points.

If the nosings are all exact, let a mould be made to fit one of them, and your nosings on the skirtings be drawn by this mould, which will likewise be exact.

**FIG. E** shews the method of laying down a raking sided stair, which is clear in itself, the height of the steps being the same on each side.

**C** and **D** shews the method of tracing one bracket from another, in a stair-case: **C** being the bracket for the common step, **D** a bracket for one of the winders.

There is shewn a method in the last plate, at **E** and **D**, for doing the same thing by means of a triangle, which is performed thus: let the other bracket at *fig. D* be given, whose length is **A B**; and if you want a bracket for the winders, whose length is **B C**, draw **B C**, making any angle at the point **B** join **A C**; take as many ordinates as you please, to touch all the principal lines of the given bracket; then draw lines parallel to **A C**, from these ordinates; and complete the other bracket as you see by the letters.

P L A T E



Plate 68.

*This Shows the Method of Skirting  
Any Stair Case*

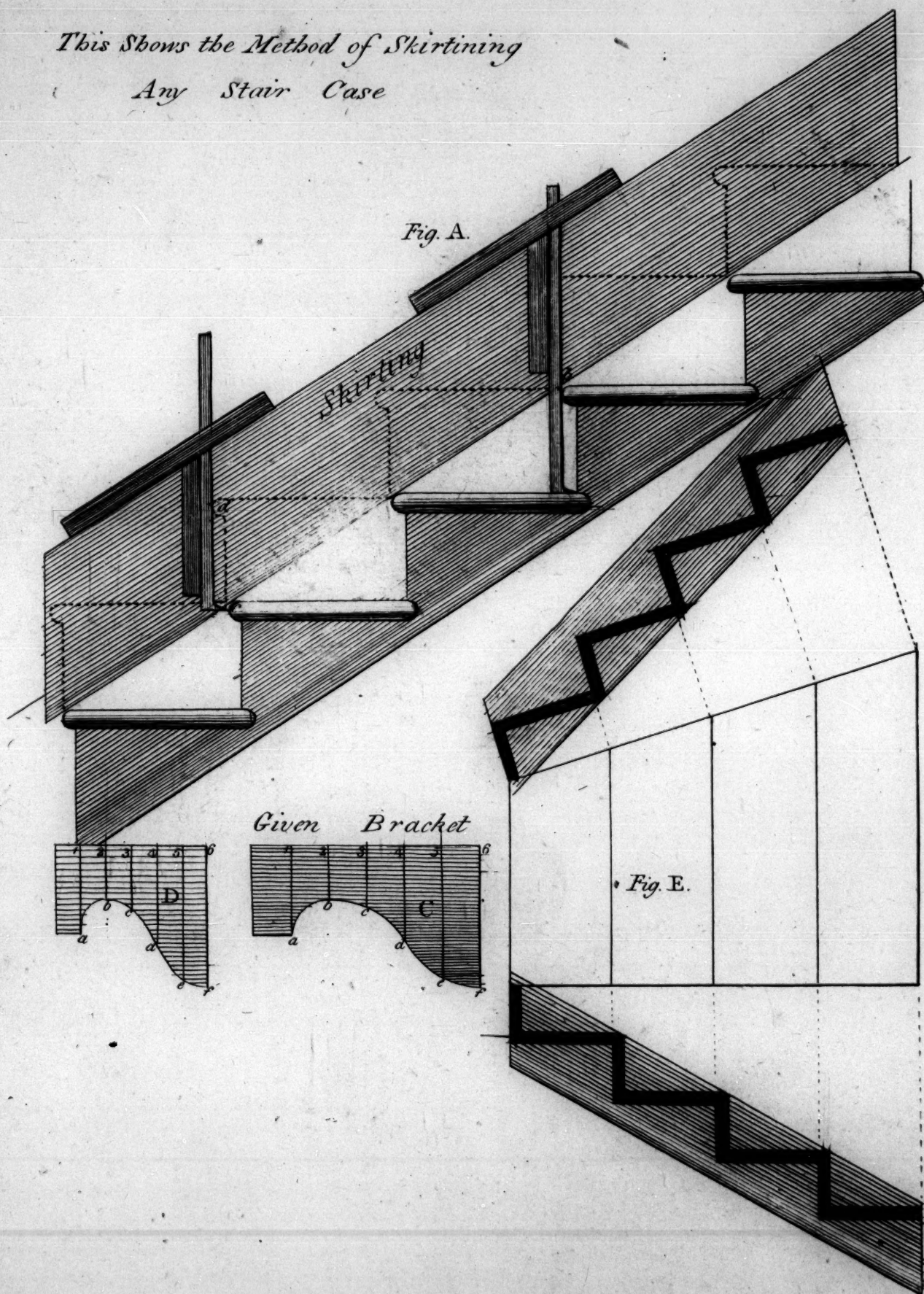




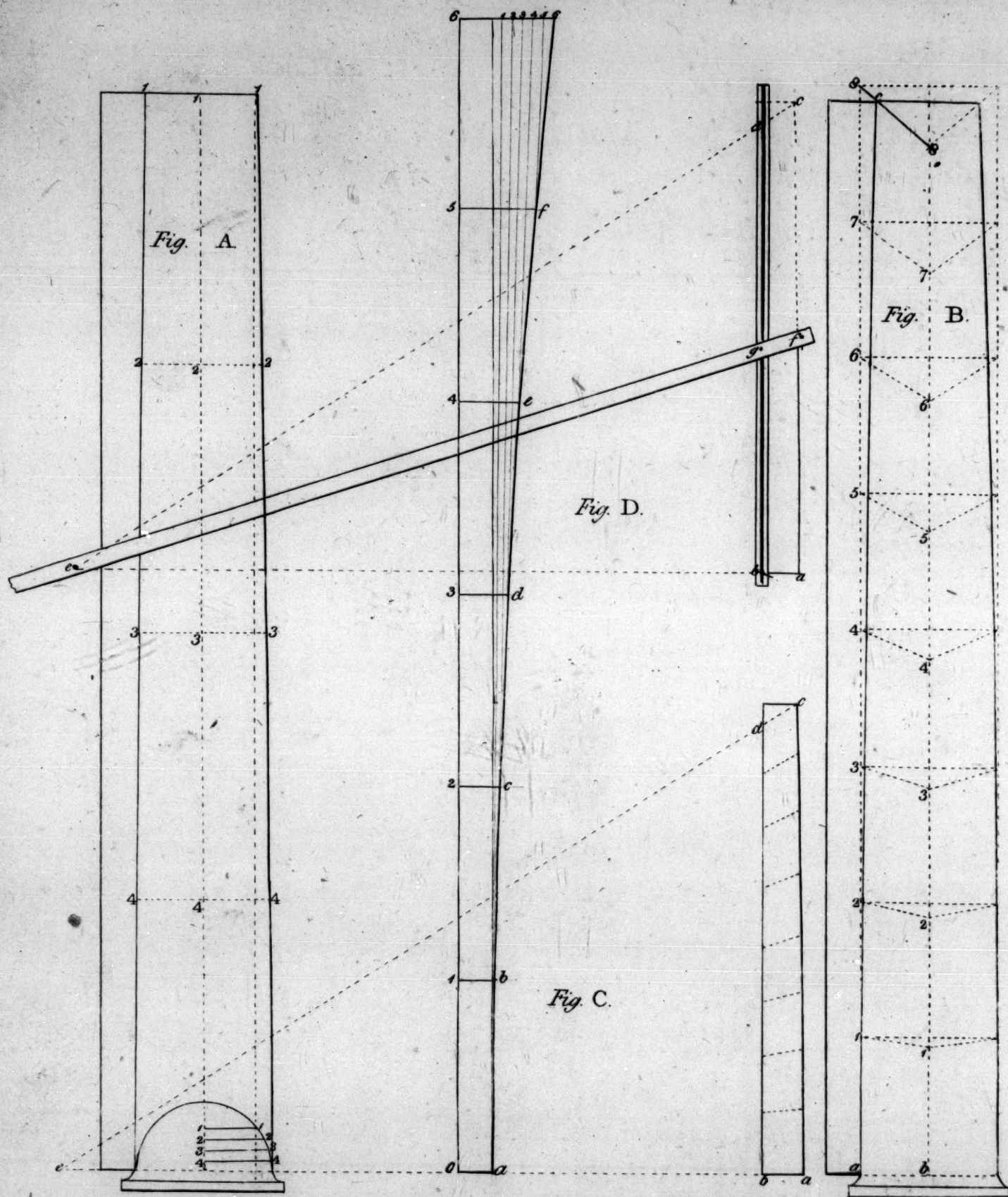








Plate 69.





## P L A T E LXIX.

*How to diminish the shaft of a column, by the ancient method.*

In *fig. A*, describe a semicircle at the bottom; let a line be drawn through the diameter, at the top, parallel with the axis of the column, till it intersects the semicircle at *i*, at the bottom; then *i i* at the bottom will be equal to *i i* at the top; divide the arch into four equal parts, and through these points draw lines parallel to the base, the height of the column being also divided into the same number of parts, and lines drawn parallel to the base, then the column is to be traced from the semicircle, according to the figures.

*How to diminish the column by lines drawn from a centre at a distance.*

FIG. C. Take the diameter *a b*, at the bottom, set the foot of your compass in *c* at the top, and cross the axis in the point *d*, continue *c d* at the top, and *a b* at the bottom, to meet at *e*; then draw from *e* as many lines across the column as you please, and take the diameter *a b* at the bottom, and prick each line upon the axis equal to *b a*, which will give the swell of the column.

*To diminish a column by laths upon the same principle.*

In *fig. D*, the point *e* being found, as in *fig. C*, take and plow a rod *d b*, and lay the grove upon the axis of the column, and plow the describing rod upon the under side, and lay the grove upon a pin fixed at *e*, and fix a pin at *g*, to run in the grove upon the axis of the column, and the distance of the pencil at *f*, equal to *b a*, then move the pencil at *f*, it will describe the diminishing.

*How to describe the column by another method.*

Take the diameter *a b* at bottom, and set the foot of your compass in the top, at *c*, and cross the axis at *8*, and draw the line *a 8* on the outside, parallel to *b 8* on the axis, and divide each of these lines into eight equal parts, and set the diameter *a b* at the bottom along the slant lines *1 1*, *2 2*, *3 3*, &c. from the axis; this will also give the diminishing of the column.

*How to make a diminishing rule.*

Divide the height of your rule into any number of equal parts, as 6; draw lines at right angles from these points across the rule, and divide the projection of the rule at the top; that is, half of what the column diminishes; into the same number of equal parts put a pin or brad-awl; lay a ruler from *a* to 5; mark the cross line at *f*; then lay a ruler from 4 to *a*, and mark the next cross line at *e*; then lay the ruler from 3 to *a*, mark the next at *d*, and so on to the bottom; bend a slip round these points, and draw the curve by it, will give a proper curve for the side of the column.

*Note.* This is the readiest method, and it gives the best curve of any that I have tried.



## P L A T E LXX.

*The plan and elevation of a circular fash, in a circular wall, being given; to find the mould for the radial bars, so that they shall be perpendicular to the plan.*

Draw perpendiculars from the points *1 1 1 1*, &c. at *A* and *B*, in the radial bars, either equally divided; or taken at discretion, down upon the plan, to *1 2 3 4 5 6 7*, at *C* and *D*; and draw a line from the first division upon the backside parallel to the base; then draw ordinates from *1 1 1 1*, &c. at right angles to the radial bars, at *A* and *B*, which being pricked from the plans at *D* and *C*, will give a mould for each bar; and the bevels upon the end will shew the application of the moulds.

*To find the veneer of the circular bar.*

To avoid confusion, I have laid down the plan and elevation for the head of the fash under. The stretch out of the veneer is got round *1 2 3 4 5 6*, on the circular bar, which being pricked from the small distances on the plan at *M*, will give the veneer above, at *E*.

*To find the face mould for the fash-head.*

Divide the fash-head round, into any number of equal parts, at *G*, and draw them perpendicular to the base at *H*; draw the chord of one half of the plan at *H*, and draw a line parallel to it to touch the plan upon the back side; then the distance between these lines at *H*, will shew what thickness of stuff the head is to be made out of; and from the intersecting points on the back side, draw perpendiculars from the base of the face mould, which being pricked from the elevation, as the figures direct, will give the face mould.

*To find the moulds for giving the form of the head, perpendicular to the plan.*

The base of *L* is got round the arch *1 2 3 4 5 6*, at *F*, and the base of *K* is got round *a b c d e f g*, also at *F*, and the heights of the ordinates of each are pricked either from *H* or *I*, which will give both moulds.

By the same method, a circular architrave, in a circular wall, may be got out of the solid.

*Note.* The face mould at *G*, must be applied in the same manner as in groins; so that the fash-head must be bevelled by shifting the mould *G*, on each side, before you can apply the moulds *K* and *L*; the black lines at *K* and *L* are pricked from the plan at *H*; these black lines will exactly coincide with the front of the rib when bent round; a line being drawn by the other edge of the moulds, will be perpendicular over its plan, and the thickness of the fash frame towards the inside will be found near enough by gauging from the outside.



Plate 70.

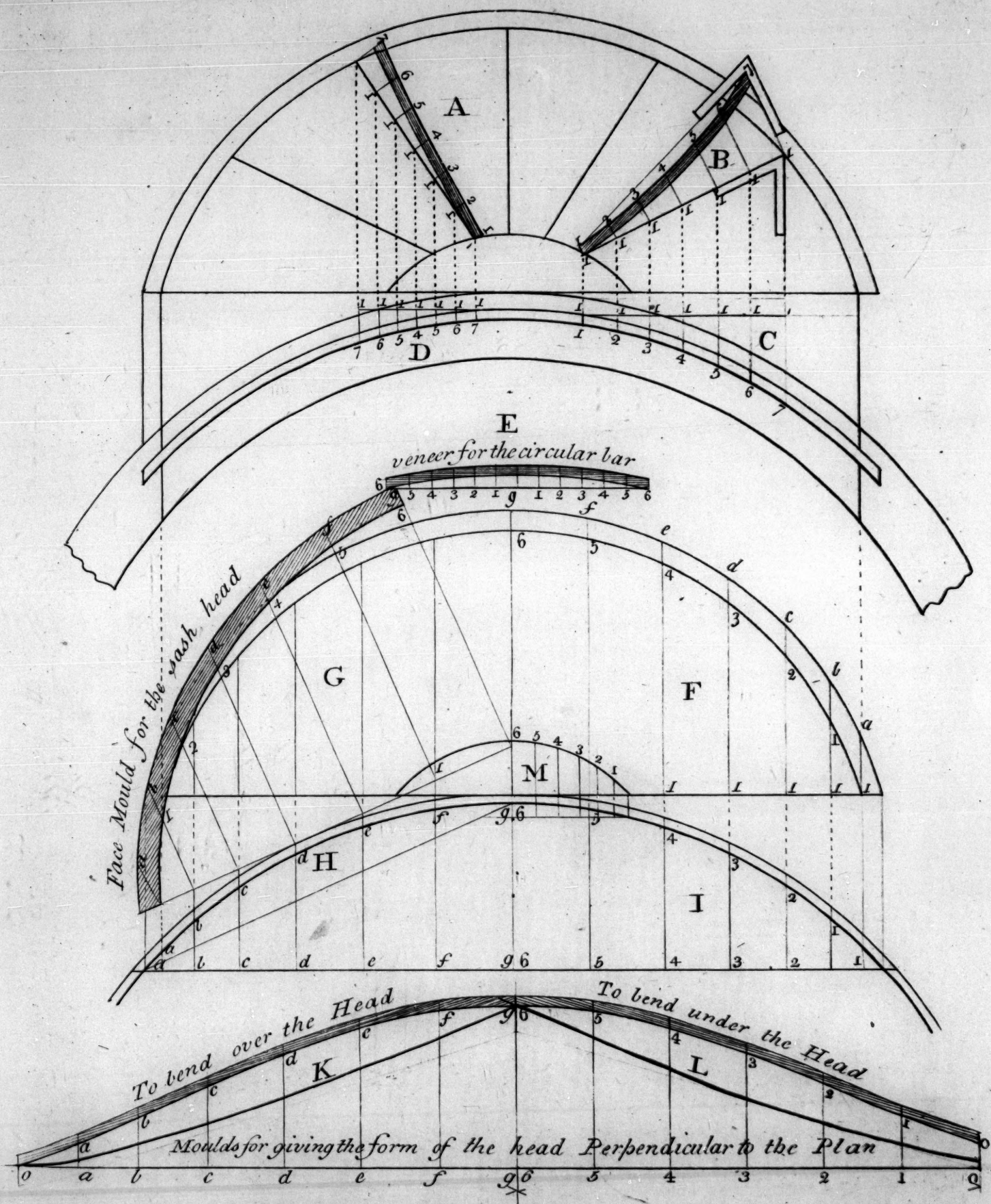








Plate 71

An Architrave or Archivolt for a Circular Window in a Circular Wall.

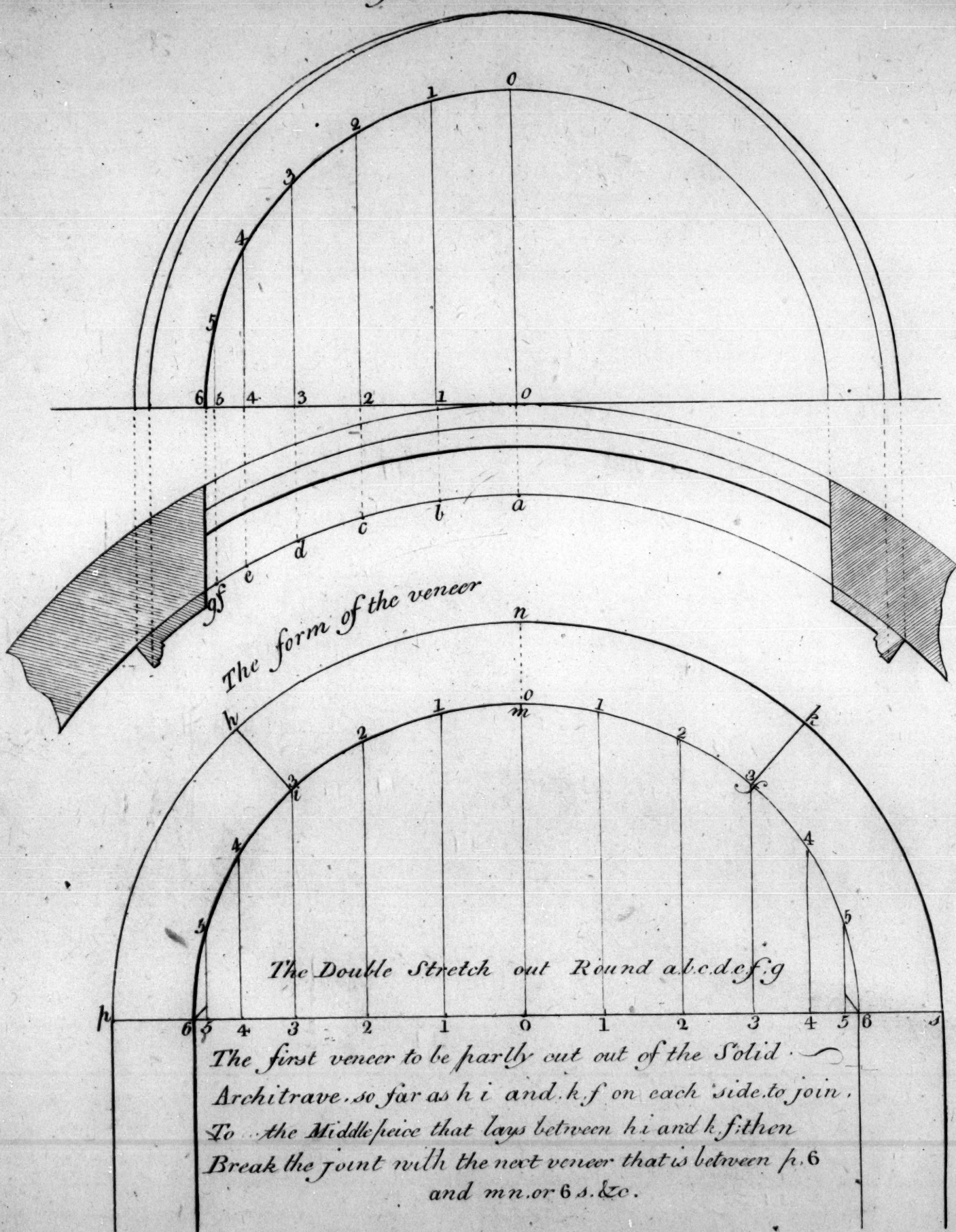












Plate 72.  
The Method of getting out angle bars for Shop Fronts.

Fig. A.

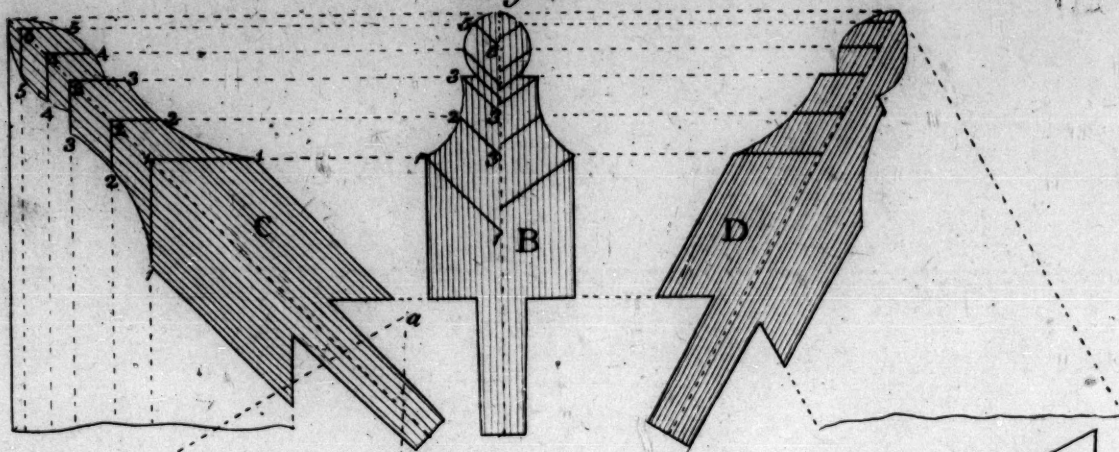


Fig. E.

Mitre of a Conode

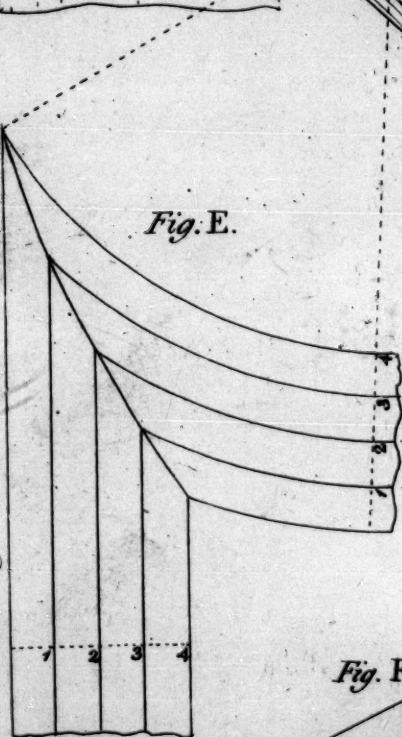


Fig. C.

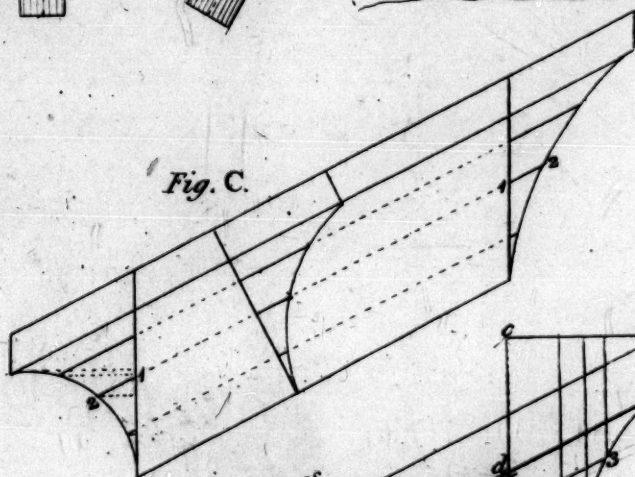


Fig. F.

Raking Mouldings

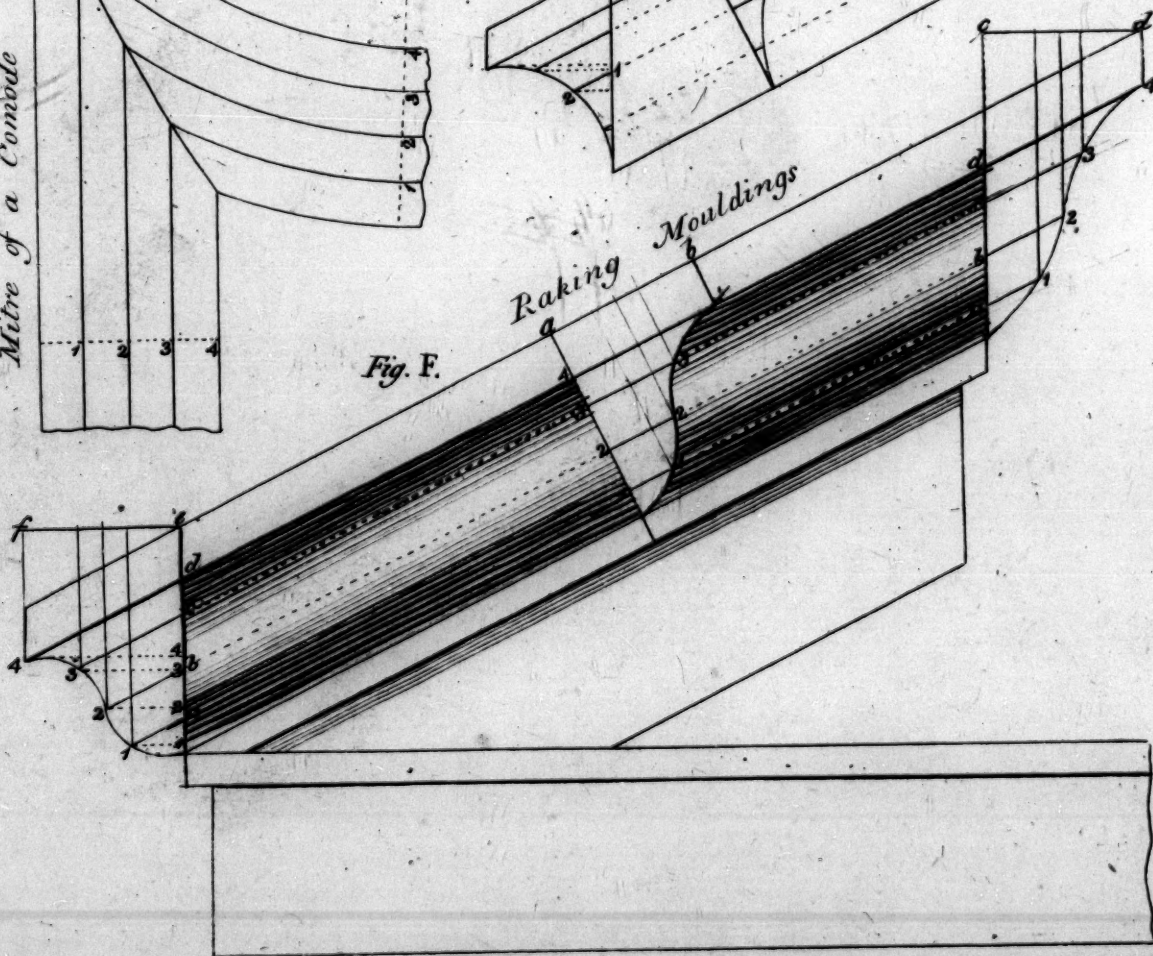
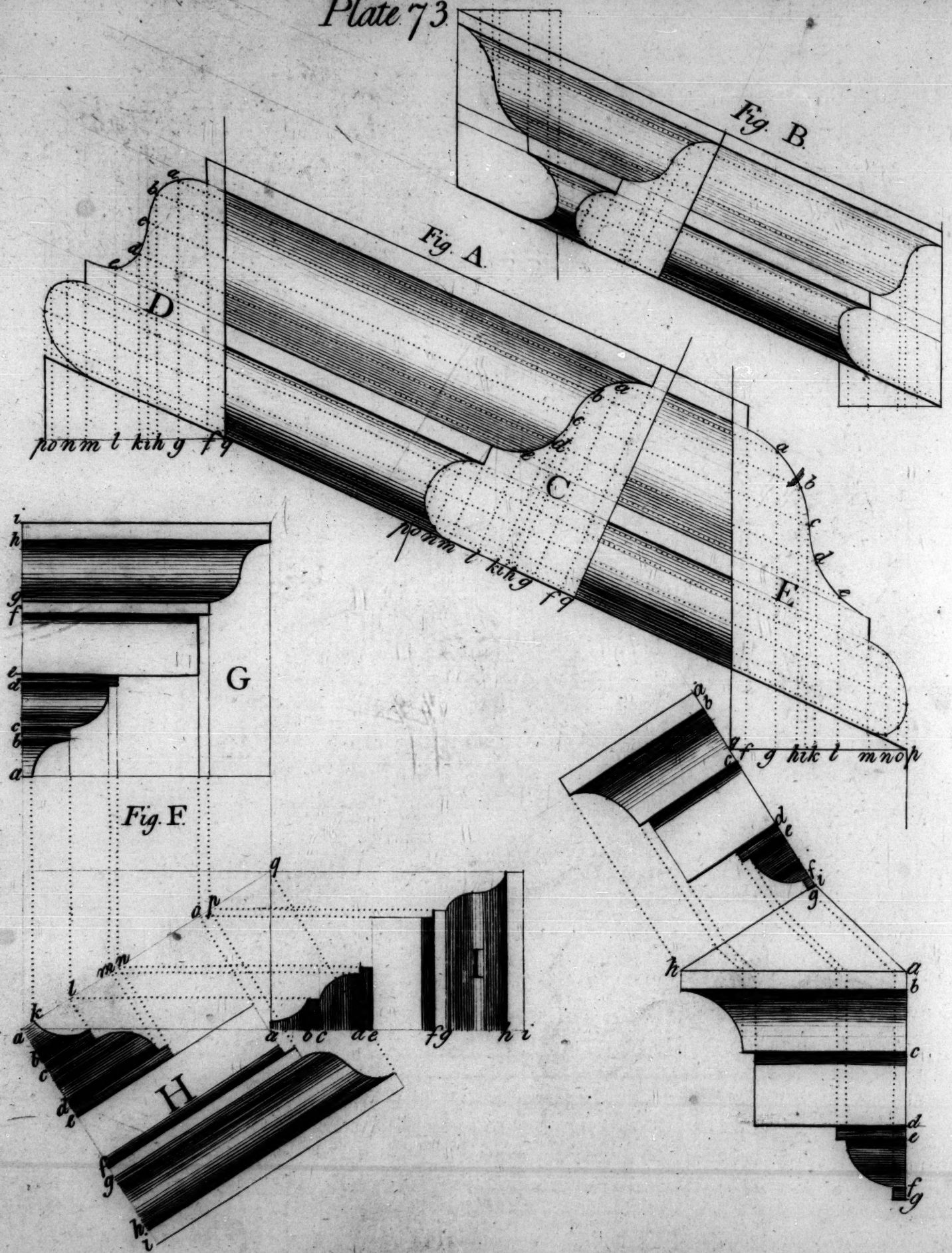








Plate 73





## P L A T E LXXII.

*To describe the angle bars for shop fronts.*

In *fig. A*, *B* is a common bar, and *C* is the angle bar of the same thickness; take the raking projection *1 1*, in *C*, and set the foot of your compass in *1* at *B*, and cross the middle of the bar at the other *1*; then draw the lines *2 2*, *3 3*, &c. parallel to *1 1*; then prick your bar at *C* from the ordinates so drawn at *B*, which being traced will give the angle bar.

*How to draw the mitre angle of a commode front for a shop.*

In *E* divide the projection each way in a like number of equal parts, then the parallel lines continued each way will give the mitre.

*How to find the raking mouldings of a pediment.*

In *fig. F*, let the cimirecta on the under side be the given moulding, and let lines be drawn upon the rake at discretion; but if you please, let them be equally divided upon the cimirecta, and then drawn parallel to the rake; then the mould at the middle being pricked off from these level lines at the bottom, will give the form of the face. The return moulding at the top must be pricked upon the rake, according to the letters.

The cavetto, *fig. C*, is drawn in the same manner.

N. B. If the middle moulding, *fig. F*, is given, perpendiculars must be drawn to the top of the middle moulding; then horizontal lines must be drawn over the mouldings at each end, with the same divisions as are over the middle moulding; and lines being drawn perpendicularly down, as above, will shew how to trace the end mouldings.

## P L A T E LXXIII.

Figures *B* and *A* shew how to trace base mouldings for skirting stairs, upon the same principle as shewn in the last plate; at the bottom are given two methods of mitring mouldings of different projections together.



## P L A T E LXXIV.

*Given the form of a cornice to draw it to a greater proportion.*

In *fig. A*, let the given height of the cornice be  $ab$ ; set one foot of your compass in  $a$ , and cross the under side at  $b$  with that height, and from the point  $c$  draw the line  $cd$  at right angles to  $ab$ ; then the height of all your mouldings will be on  $ab$ , and the projections on  $cd$  in proportion to  $ab$ .

*Note, af shews another height, ce its projection in proportion to that height.*

*How to diminish a cornice in the proportion of a greater.*

Describe equilateral triangles on the base and projection as at  $D$ , and make  $if$  and  $ig$  equal to the intended height, and draw the line  $fg$  across the triangle, which will give the heights in proportion to  $ab$ ; put the foot of your compass in  $b$  as a centre, and circle  $bc$  round to  $bb$ , and draw the dotted line  $bi$ , cutting  $fg$  in  $k$ ; then set off  $ie$  and  $id$ , each equal to  $gk$ ; draw  $de$ ; then take the divisions of  $ed$ , and set them from  $f$  to  $m$ ; in the same orders draw perpendiculars: it will give the diminished cornice at  $D$ .

*Another method.*

At  $E$ , let the given height be  $ab$ , and draw the hypotenuse  $ag$ , and lines being squared up to  $ab$ , from the divisions of  $ag$ , will give the heights; and if you draw the line  $gd$  at a right angle with  $ag$ , then  $dc$  will give the projection in proportion, when returned upon  $dc$ .

*FIG. C is the method for hanging a jib door.*

Let  $ac$  be the projection of the surbase or base moulding, and  $c$  the centre of the hinge; make  $ab$  equal to  $ac$ , and in the centre at  $c$  describe the arch  $bde$ ; then the arch  $bde$  will be the proper joint for the surbase to work in.

The joint of the surbase or the base may also be straight, as you see by the dotted line touching the circle at the point  $b$ , as a tangent to it.

## P L A T E LXXV.

*To find the sweep of a moulding to be bent upon the spring round a circular cylinder.*

In *fig. A*, which stands upon a semicircular plan, set  $ac$  to the height of your moulding, and make  $ab$  the projection; draw the form of your moulding, and draw a dotted line to touch the face of your moulding; then draw the line  $ed$  to meet in the centre of the body at  $d$ , so as to keep your moulding to a sufficient parallel thickness; then in your centre  $d$  describe your moulding.

*How to find the sweep of your moulding when the plan is a segment.*

Complete the semicircle as in plate 1, *fig. 1*, then proceed as described in *fig. A*.

FIGURES *C* and *D* shew the method for bending a moulding round the inside, which is performed the same as above.

The demonstration may easily be conceived from the covering of a cone.

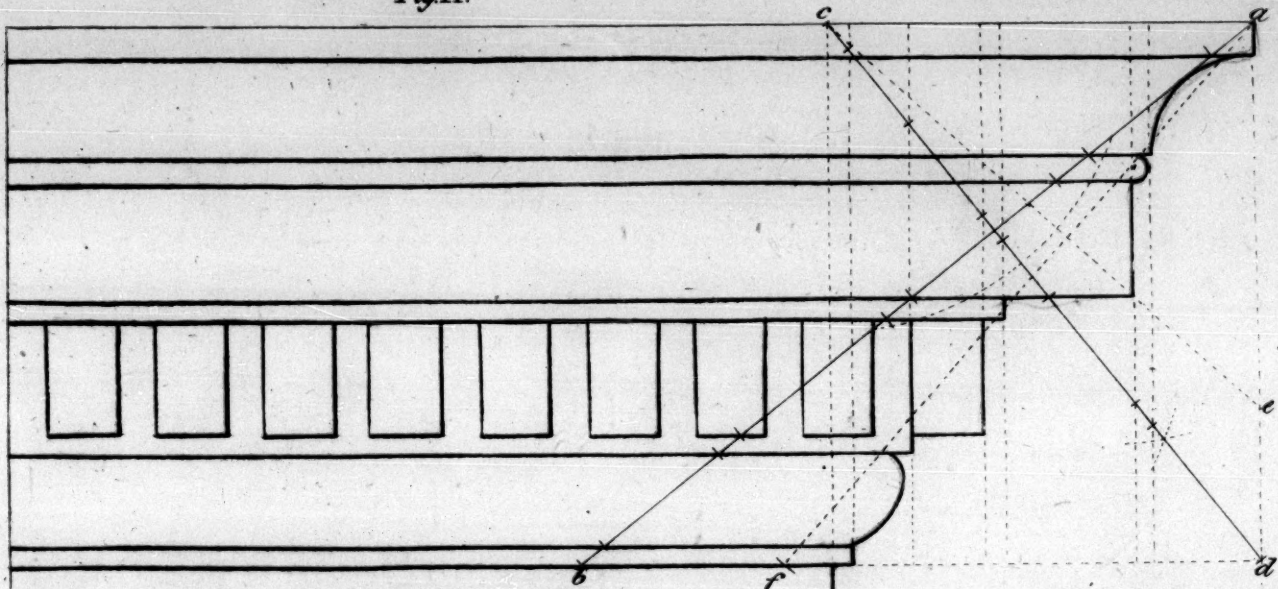
C O N.



Plate 74.

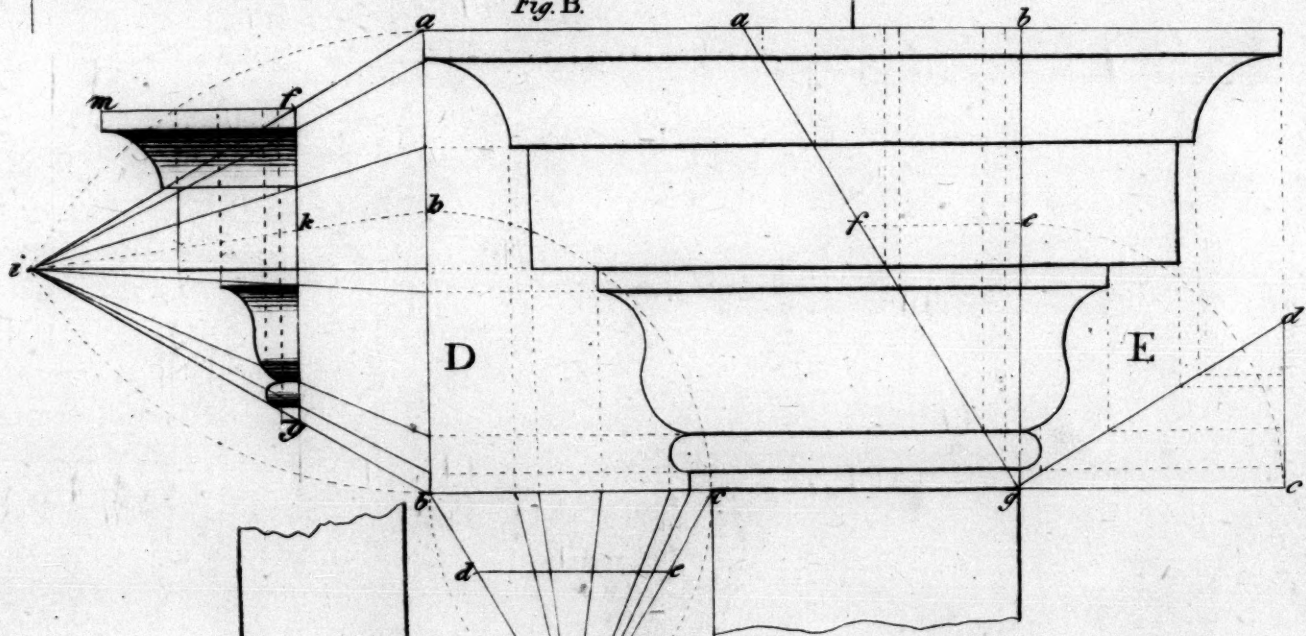
This shows the method of enlarging cornices.

Fig. A.



This shows the method of diminishing cornices

Fig. B.



This shows the method of hanging a jib door

Fig. C.

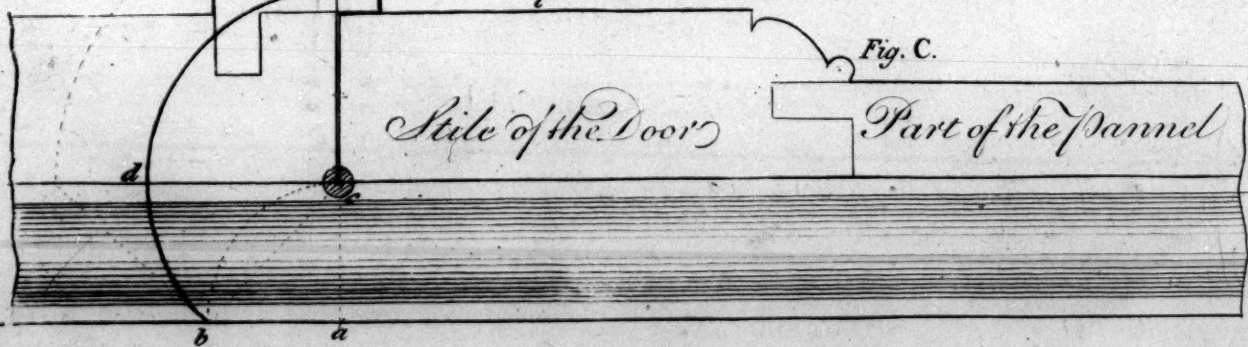








Plate 75.

Fig. A.

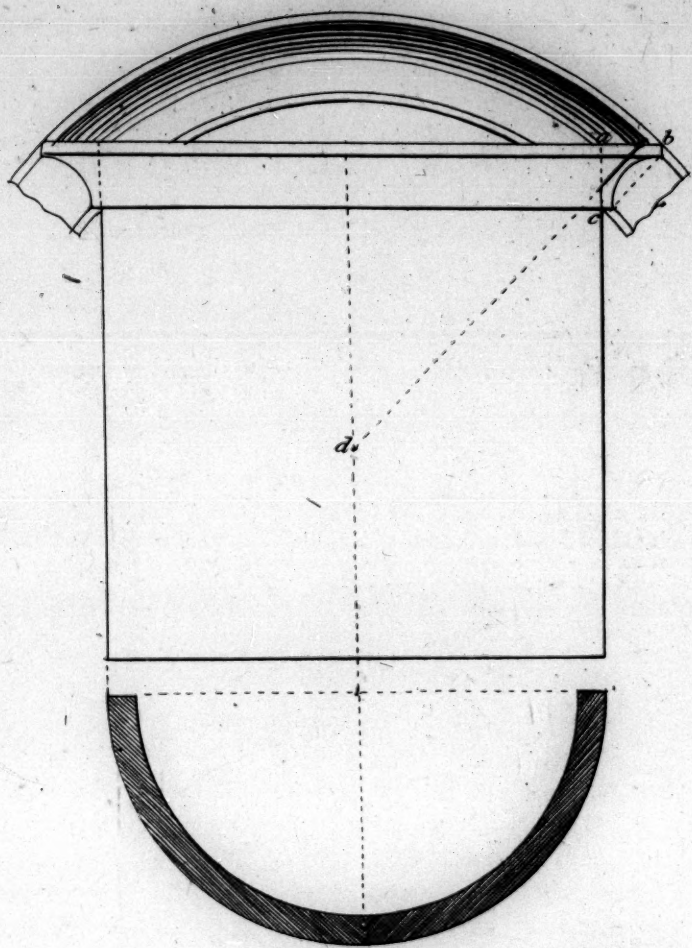
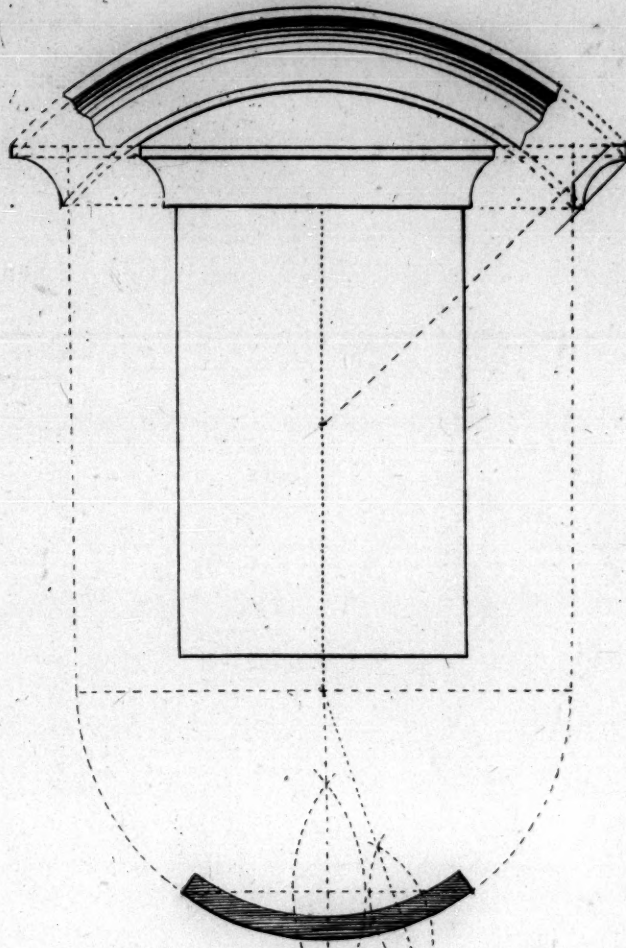


Fig. B.



*This Plate shows the different methods of bending cornices out of the solid.  
to stand to any Spring*

Fig. C.

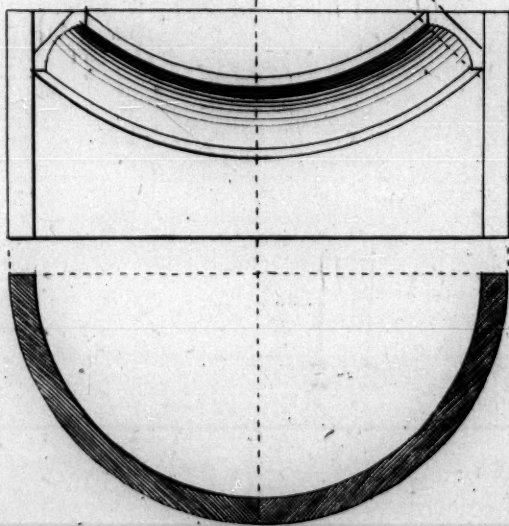


Fig. D.

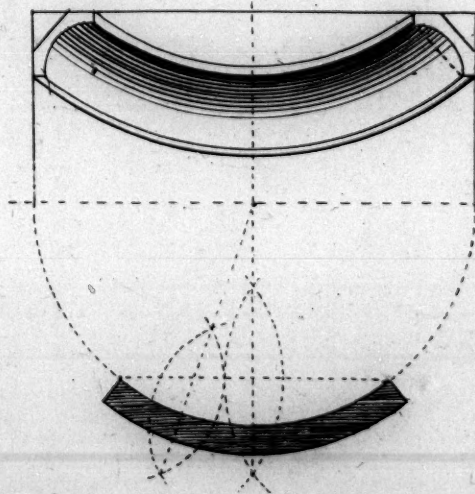












Plate 76

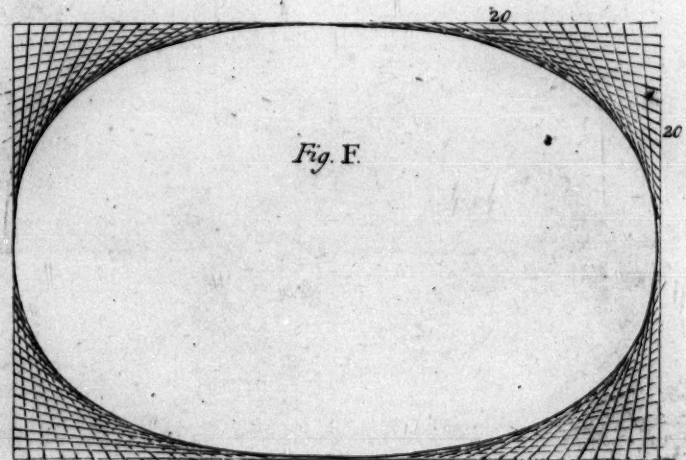
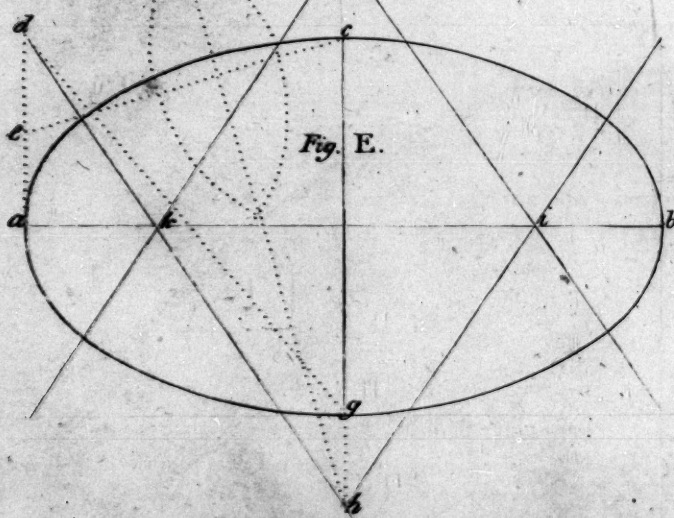
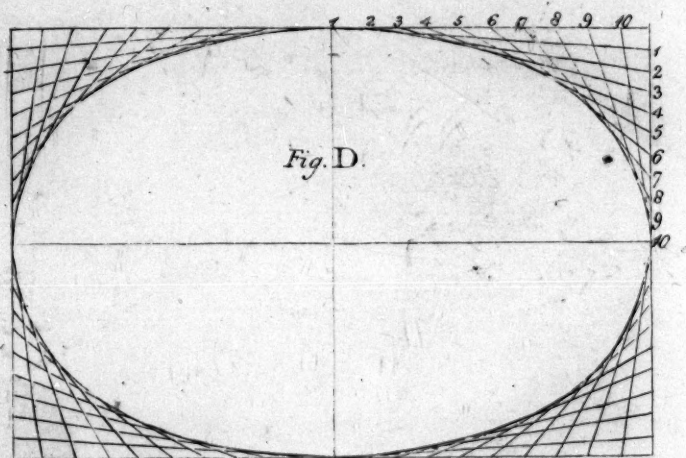
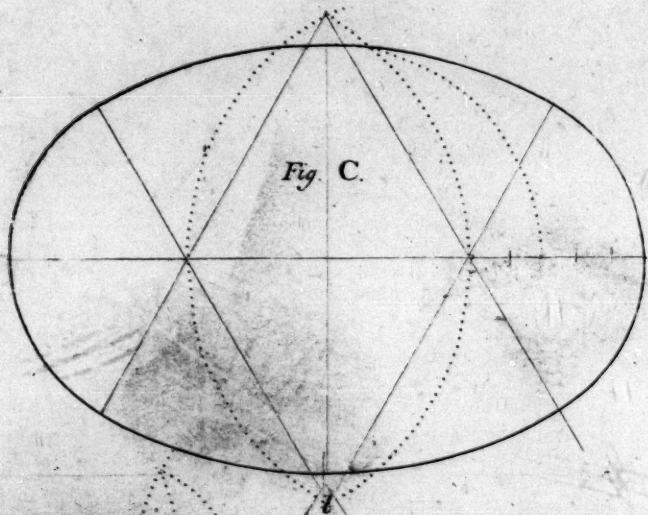
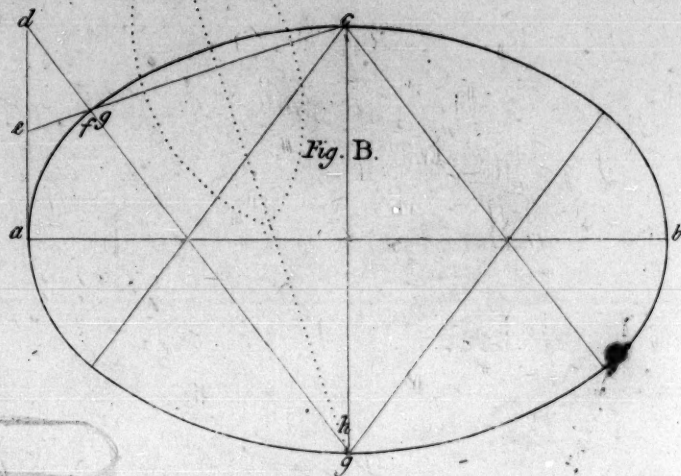
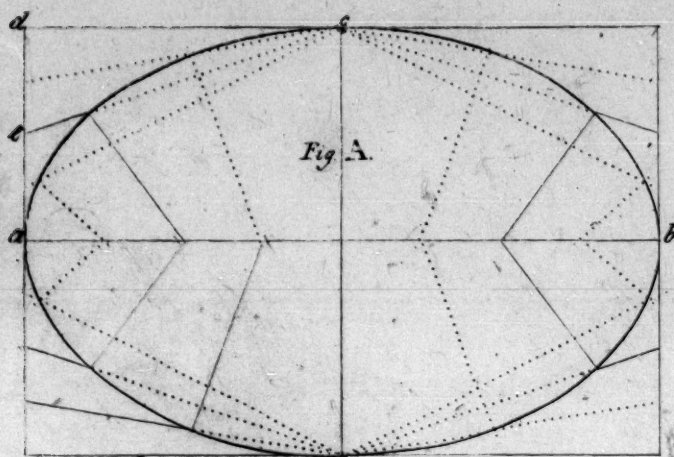
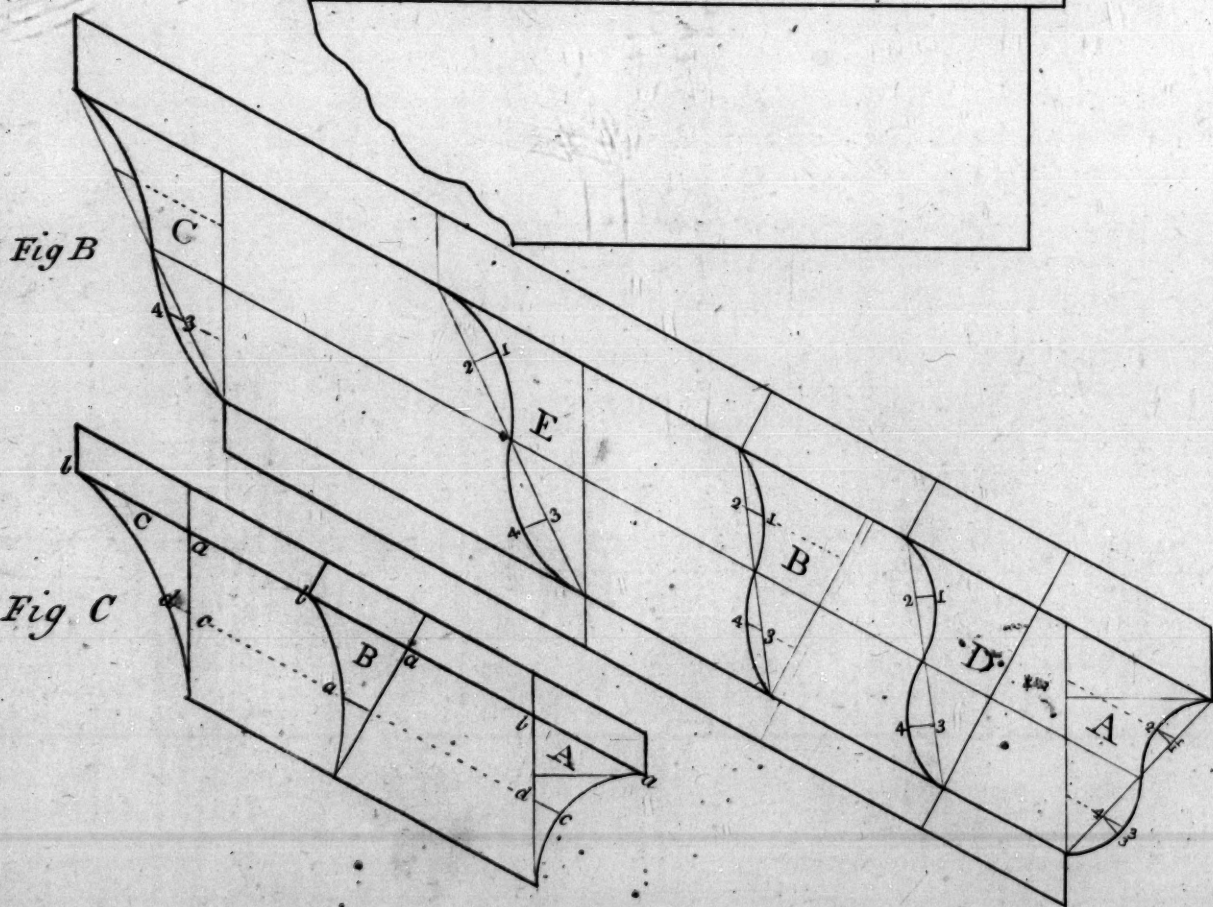
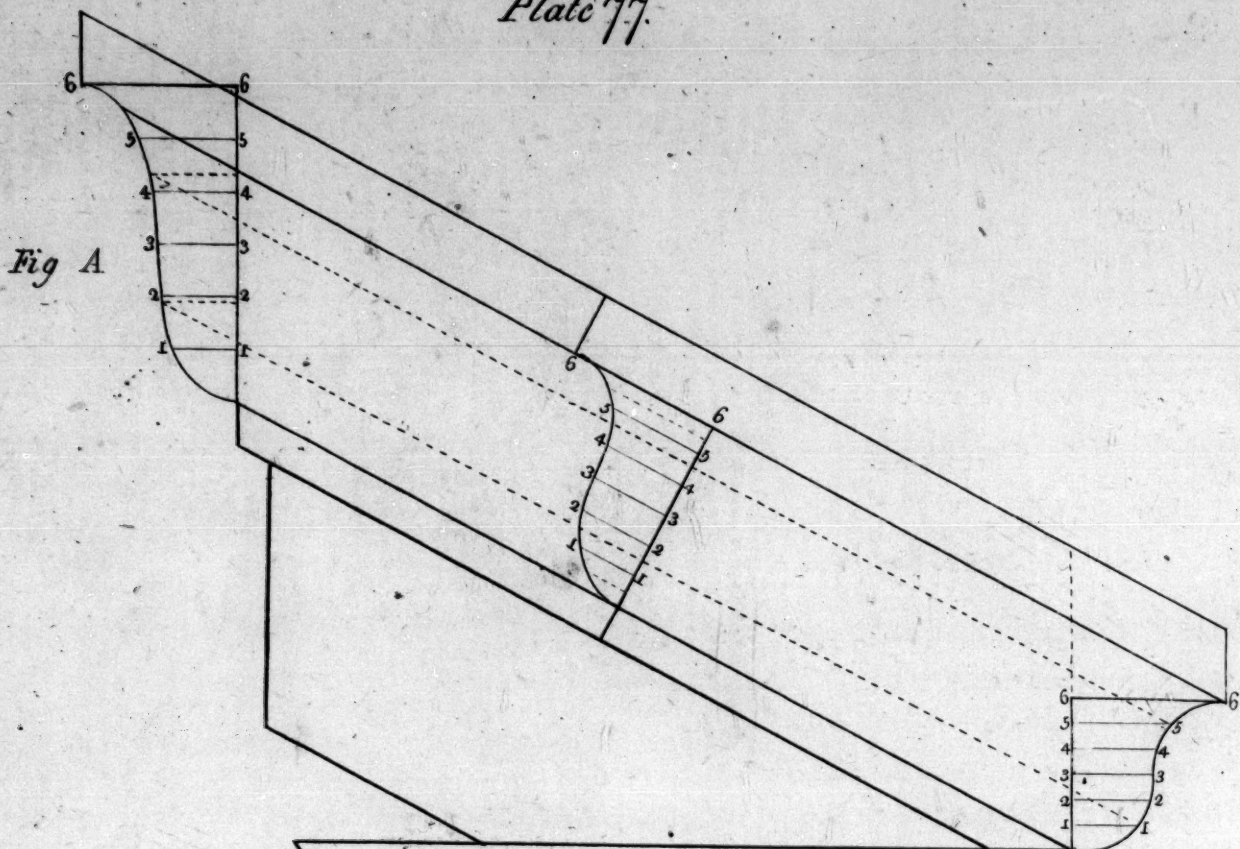








Plate 77.





## C O N C L U S I O N :

In which are examined, by way of preventive Caution to the Student, several prevailing Methods, which are founded on wrong Principles, and better ones here proposed.

### *Of the Ellipsis. Plate 76.*

THE old manner of intersecting all kinds of lines, applied to gothic and elliptical figures, to this day is exceedingly useful in forming the ramps of stairs, or easing off any angle, as at *G*; but when this is applied to elliptical figures, it is far from forming a true ellipsis, being too full at the ends, as at *fig. D* and *E*: and this is no certain rule for drawing an ellipsis, for the more divisions there are, the worse is the ellipsis; as for example, *fig. F* is divided into double the number of parts as *D*; it is plain that neither *D* nor *F* is an agreeable ellipsis, and *F* is much worse than *D*, which is contrary to general opinion; for I have been frequently told, the more parts it is divided into, the truer it is; but by this it appears the more parts it is divided into, the worse it is: if this is doubted, try it. *Fig. A* is an ellipsis drawn on true principles, as laid down in Plate 7, at *C*, of this book, and is here repeated to be compared with the others. *Figures B, C, and E*, are ellipses drawn with a compass: I may call them representations, as it is impossible to draw them true with a compass; there is no part of the curvature of an ellipsis that will exactly agree with any part of a circle, for in every quarter of an ellipsis, from the extremity of the transverse, the curvature in every succeeding part is continually flatter towards the extremity of the conjugate axis; but yet there is a method to represent an ellipsis, which will differ very little from the truth, as is shewn at *figures B* and *E*, which are both drawn by the same method; *fig. E* or *B* is the nearest to the shape of *fig. A*; *fig. C*, the method used by almost every author who has written upon the subject, is full at the ends, but not in so great a degree as *fig. D* and *E*.

### *Of raking Mouldings. Plate 77.*

In Plate 77, *fig. A*, let the moulding at the bottom be given, and let the perpendicular height be divided into any number of equal parts, as six; likewise divide the perpendicular height of the top moulding into six, and the face moulding into six, at right angles to the rake; and let the ordinates of each be drawn through the equal divisions of each respective perpendicular, and pricked from the bottom, as the figures direct. It is evident, that if the under moulding is composed of two quarters of a circle, the upper mouldings will be composed of two quarters of an ellipsis; consequently the return moulding at the top will be too quick upon the round, and likewise in the hollow.

But:



But if this demonstration should not be sufficient, let a dotted line be continued from 1, in the given moulding, parallel to the rake; then it will be evidently seen, that this dotted line corresponds with neither the face nor the return moulding; for in the face moulding it falls between the points 1 and 2; and in the top moulding it falls almost at the point 2; whereas it should only come to the point 1 in each; but the horizontal projection from 2 to 2, at the top, ought to be equal to 1 1 at the bottom; but it is much greater: therefore this method is false, as they will not mitre together.

I shall also notice another method used by some authors, see *figure B*, at *D* and *E*, where they are pricked perpendicular to their chords, in the middle, which is also false; but if they are pricked as at *B* and *C*, on the rake, will be exceedingly near, if described with a compass through three points.

*Of diminishing of Columns. Plate 78.*

The method for drawing a column, described by some authors, and which is properly called a conchoid column, is not only very inconvenient on account of the cumbersome instrument which is necessary to find the curve for practice, but also the appearance is, I think, less graceful than when produced by other methods. The conchoid curve, or column, is concave towards the bottom, and convex towards the top; and if this curve was infinitely extended, it would never meet the axis; which shews it to be different from the elliptic curve or column, as some have called it.

The column called hyperbolic, plate 78, is not so named from the general properties of the conic hyperbola (because there may be an infinite number of hyperbolas standing upon the same base, having one common vertex, which will all be contained between a triangle and a parabola, according as its axis is longer or shorter), but because it will nearly coincide with some of these hyperbolas. This curve has been known among workmen, and by them has been mistaken for an elliptic curve; to refute which I have, on the same plate, shewn a true elliptic column for comparison; the lines of their curvature are continued only to shew their true figure; either of these is a more commodious method than the conchoid.

The method which I recommend as easiest in practice for diminishing of columns is already described on plate 69, by means of a diminishing rule, which is infinitely more convenient than the trammel, and which, to my eye, also produces a pleasanter contour; but as this will depend on the fancy of the architect, the workman will find some of the methods shewn will answer his purpose for any curve. The conchoid is flattest at the top, the hyperbolic is a little quicker, the parabolic is still more so, and the elliptic is the most quick.

F I N I S.



